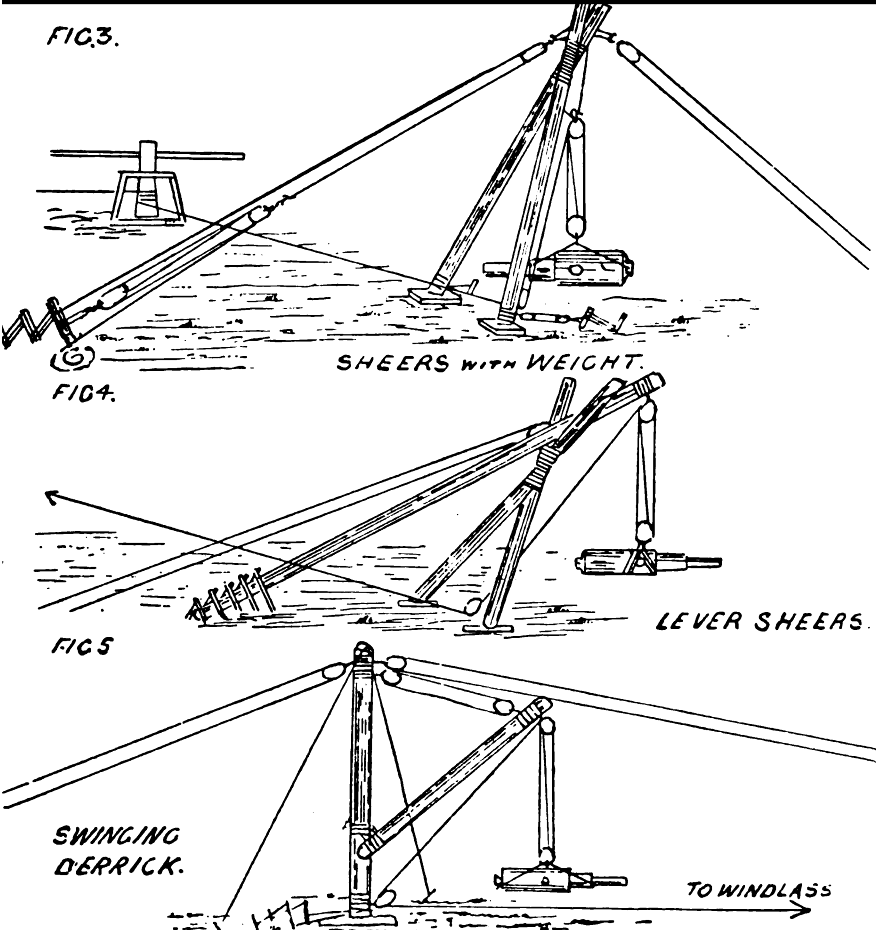

Handbook of artillery matériel

Frederick Cyril Morgan

HANDBOOK

OF

ARTILLERY MATÉRIEL.

BY

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WITH PLATES.

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PREFACE.

In the following work containing a short description of ordnance, ammunition, carriages, machines, and stores used in the service of artillery, the compiler has endeavoured to provide in a concise and handy form the most important and most recent information.

It is hoped that the handbook may prove of use to those officers and others, who, from various causes, have not had the time and opportunities to keep themselves up to date with the constantly recurring changes.

It is further thought that it may provide for a want felt by officers of the Auxiliary Artillery who may require a knowledge of artillery *matériel* in a condensed form. By illustrating the work with nineteen plates, it has been possible to shorten the description in many cases.

Thanks are due to Colonel F. G. Baylay, R.A., Chief Instructor in Gunnery and Associate Member of the Ordnance Committee, who has kindly corrected the proofs when necessary, and to Major L. Downes, R.A., late Instructor Royal Gun Factory, for his information on the new B.L. Guns.

F. C. M.

R. M. Repository, Woolwich,
November 1884.

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HANDBOOK

OF

ARTILLERY MATÉRIEL.

PART I.

ORDNANCE.

CHAPTER I.

METALS USED IN GUN CONSTRUCTION.

Metals.—Iron and bronze are the only two metals that have been found suitable for gun construction, either in past or modern times.

Iron.—Iron is used in the form of cast iron, wrought iron, and steel; these three, owing to the very different properties they possess, are commonly known as distinct metals.

Cast Iron.—Cast iron is obtained from iron ore by the process of smelting, the molten iron being run off into moulds and termed pig or cast iron; it contains from two to five per cent. of carbon, the process of smelting having removed the greater proportion of other impurities existing in the ore. The carbon may partly exist in it in an uncombined state as in grey iron, or be perfectly combined as in white iron, mottled iron being between those two.

Cast iron is hard, but weak and brittle; it can be easily melted and so moulded into any shape, but if heated and then hammered it will fall to pieces.

Its inherent weakness renders it quite unsuitable as a material for rifled ordnance, but for smooth-bored guns it was a cheap and sufficiently strong metal, and there still exist in the service a large number of cast-iron S.B. ordnance.

Wrought Iron.—Wrought or bar iron is manufactured from cast iron by the operation of puddling; the object of the latter process being to remove nearly the whole of the carbon.

This is effected in the following manner in the Royal Gun Factories; pig and cast iron scrap which is broken up under a hammer into pieces of convenient size, are placed in a reverberatory furnace, where the metal soon melts: it is then stirred by the workman and the carbon passes off in the form of carbonic oxide: the iron then becomes pasty and is collected by the puddler into large balls, which are removed from the furnace to a steam hammer, and the ball is then hammered into a rectangular block termed a "bloom."

Wrought iron contains not more than three parts per 1000 of carbon. It cannot practically be melted, but can be heated and hammered into any shape, also by rolling or by drawing it out under a hammer it can be made fibrous, and consequently very strong in the direction of its fibre; it is ductile, malleable, and tenacious, and can be welded, that is two portions joined together by heating and hammering; it is not a very elastic metal, though twice as elastic as cast iron.

Owing to its ductility it will stretch permanently if strained beyond its limit of elasticity, but will not under ordinary circumstances split with violence like cast iron. It is soft and liable to defective welds, and has hitherto been considered an excellent material for the inner portions of a rifled gun, but not suitable for the interior barrel.

Steel.—Steel is iron mixed with a certain proportion of carbon. Any mixture of iron which can be melted in a furnace in large quantities and afterwards worked under a hammer or rolled out is really steel. Approximately, iron can be so treated which contains between 0·3 and 2 per cent. of carbon.

Steel then lies between cast and wrought iron, and possesses the valuable properties of both, for it can be melted and moulded and afterwards worked under a hammer or forged.

After casting and forging it requires hardening: this is effected by heating it to a proper temperature and plunging it in oil in which it cools slowly; it then becomes hard and tenacious, without having too great a degree of brittleness. The limit of elasticity of steel is high, but after that limit is passed it is liable to fly to pieces.

The only parts of the R.M.L. guns that are made of steel are the inner barrels or A tubes; the metal, owing to the hard smooth surface that can be imparted to it, was thought specially suited for the bore of the gun. Further, the tube if unduly strained, though it might split, would never stretch permanently and so deform the bore; whilst the exterior portions of the gun being built up of wrought iron with the fibre running circumferentially, imparted

great strength and would, it was thought, in the event of the inner barrel splitting prevent an accident.*

Modern improvements in the manufacture of steel, both as regards economy in the processes of casting and also in its quality, have modified to a great extent the considerations as to the best material for the exterior portion of a rifled gun; and the breech-loading guns of the new type are now made entirely of steel.

Mild steel is manufactured in the Royal Gun Factories as follows:—proportions of pig iron both hæmatite and Swedish iron, blooms of wrought iron, steel turnings, steel scrap, i. e. lumps of steel from various sources, are placed in a reverberatory furnace and stirred up in a molten condition for several hours, varying according to the charge in the furnace, until only 0·29 per cent. of carbon exists in the metal. Spanish ore containing very little carbon or pig iron is added as required. The amount of carbon present is tested by the foreman, who removes a little of the steel in a spoon at the end of a rod, and by hammering, bending, and breaking the sample, judges when the furnace is ready for tapping. A small proportion of manganese and silica is added at the finish to impart toughness. The molten steel is then run off into a large ladle, and from that, by means of an aperture in its bottom, into cast-iron moulds or jackets placed underneath it.

As the ingots of steel thus cast cool, the moulds are easily removed; the shapes of the ingots are solid cylinders, or cylinders square in section with the edges rounded off, or eight-sided cylinders, according to the use for which they will be required; they are afterwards forged and tempered. They vary in weight up to 12 or 15 tons.

Bronze.—Bronze is an alloy of 90 parts of copper and 10 of tin; that particular kind used in the service being known as gun-metal. It is soft and easily damaged by the projectile in the bore of a gun, and is soon acted upon by heat, even that caused by the firing of a few rounds: and in the process of casting, tin spots are liable to be found owing to the tin separating; these are acted on by the powder gas and soon form flaws in the bore. Though a tough and tenacious metal, it is for the above reasons found quite unsuited as a material for a rifled gun. The only bronze rifled guns in the service are a few 7-pounders; there are, however, many bronze smooth-bore pieces of ordnance.

* Guns with steel A tubes, strengthened externally with wrought-iron coils, have in a few instances been known to burst explosively.

CHAPTER II.

RIFLED MUZZLE-LOADING BUILT-UP GUNS.

Construction of R.M.L. Guns.

Until about the year 1854 all ordnance were constructed of cast iron or bronze, and were smooth bored: these metals were found sufficiently strong and otherwise suited for the purpose. But the introduction of rifled ordnance necessitated a stronger metal being employed, owing to the greatly increased strain on discharge that occurs. This increased strain being due to the fact of elongated projectiles being introduced to which both rotatory and forward motion had to be imparted: whereas in the case of a smooth-bored gun, the spherical projectile experiences but slight resistance, being merely that due to its "vis inertiæ" and to the elevation of the piece.

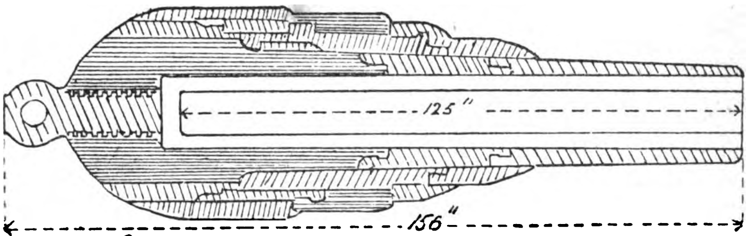
Not only was wrought iron in conjunction with steel substituted for cast iron or bronze in our rifled guns, but in order to give great additional strength, the guns were constructed or built up in layers with a view to each layer bearing its fair share of the strain on discharge from the interior to the exterior. In the case of a solid mass of metal it may happen that the inner portion of it yields to a pressure from within before its outer portion has been strained to its limit of strength. Further, advantage was taken of the fibrous condition to which wrought iron can be brought by rolling and hammering, and the fibre was arranged so as to give to the metal the greatest powers of resistance to rupture; being made to run circumferentially round the gun to withstand the transverse strain on discharge, and longitudinally over the breech to resist the longitudinal strain that occurs.

The earliest rifled guns were of the Armstrong original construction: the gun was built up of several small coils of wrought iron shrunk on over an inner barrel of steel which in the earliest patterns was also of wrought iron: the outer portions of the gun being thus in a state of tension and the inner tube in a state of compression. A forged breech-piece was placed over the powder-chamber, the fibre running lengthways (Plate I. Fig. 1).

The Woolwich system is a modified form of the same, the coils being made larger and fewer in number, and a coiled breech-piece is substituted for the expensive forged one originally employed:

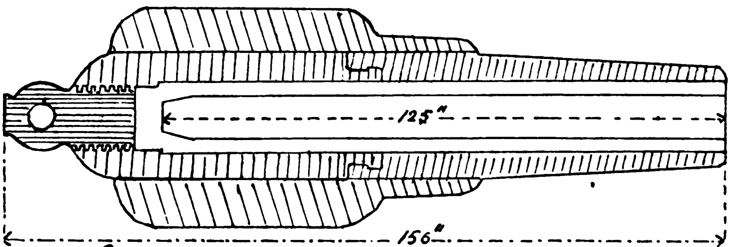
PL. I.

FIG. 1. SCALE 1/42



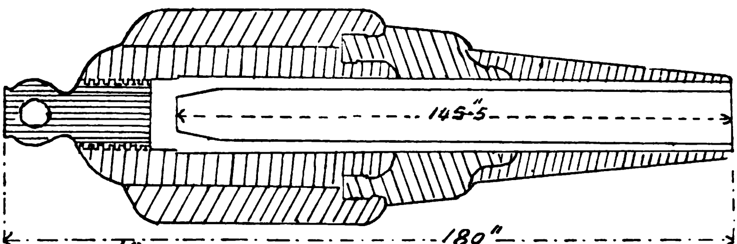
9-INCH R.M.L. GUN OF 12 TONS MARK I.

FIG. 2. SCALE 1/42



9-INCH R.M.L. GUN OF 12 TONS. MARK V.

FIG. 3. SCALE 1/48



10-INCH R.M.L. GUN OF 18 TONS MARK II.

[To face p. 4.

the breech end of the steel tube is solid and is supported by a cascable screwed up against it through the breech (Fig. 2).

On this latter system all the R.M.L. built-up guns in the Service have been constructed for some years, and a description of the process of manufacture of a 10-inch R.M.L. gun of 18 tons will serve as an example of them all (Fig. 3).

It must be remembered that guns of this type, which may be termed old-type guns, are not now being made: the modern or new-type B.L. guns at the present time being constructed, differing considerably in their manufacture; but the principle of building up the parts which are of steel remains the same.

However, as the armament for land service consists for the most part of R.M.L. guns of the old type, a knowledge of the details of their manufacture is essential.

Processes of Manufacture of R.M.L. Guns.

A Tube.—The inner barrel or A tube is made out of a solid ingot of steel which is cast in the form of a solid cylinder and afterwards forged under a steam hammer and drawn out to the required length. In this state it was supplied by contract to the Royal Gun Factories. A slice is then cut off the breech end and divided into pieces for testing: after testing it is roughly bored out and then toughened by heating it to an approved temperature and plunging it in oil: after this a water-test of 4 tons on the square inch is applied to detect any flaws by moisture.

Manufacture of a Coil.—A coil is made as follows: Flat bars, about 2 cwt. in weight, are formed by heating and welding together two blooms of wrought iron which are then rolled out. These flat bars are then piled or faggoted together, the outer ones being of puddled iron, which gives a smooth surface, the inner ones of scrap iron, which forms a strong fibrous bar: the number of flat bars depending upon the size of the coil required (Plate II. Fig. 1).

Scrap iron consists of old wrought-iron articles such as horse-shoes, bolts, nuts, nails, &c., which are heated and welded together.

The pile of flat bars is then heated to a welding heat and rolled into a bar about 24 feet in length, and varying in section, which is trapezoidal. The rolling is effected in the rolling-mill, where the bar is made to pass backwards and forwards between rollers, by which its sectional area is continually diminished and its length increased. By this means, also, a fibre is given to the bar in the direction of its length.

The bar, or two bars welded or scarfed together if necessary to make up the required length, is then placed in a long furnace,

in front of which is a conical mandril, to which the bar is attached by a loop at its end; the mandril is made to revolve, and the bar coils itself round, the narrowest surface of the bar pressing against the mandril (Fig. 2).

As soon as the coiling is complete the mandril is up-ended, and the coil drops off, and is afterwards heated to a white heat, and hammered under a steam hammer, both in a horizontal and vertical position, to weld the folds together.

The coil, or hollow cylinder of wrought iron thus formed, with the fibre running round it circumferentially, is then turned and bored to finished dimensions (Fig. 3).

Manufacture of the B Tube.—A "B" tube is composed of two single and slightly tapered coils united together. A shoulder is made in one and a recess in the other, termed a spigot and faucet, the faucet of the recessed coil being then expanded by heat and allowed to shrink round the shoulder or spigot of the other. The tube is again heated to a white or welding heat, and the joint completely welded under a steam hammer.

Manufacture of a Jacket.—A breech coil, "C" coil, or jacket, is composed of three parts—a breech coil, trunnion ring (forged), and muzzle coil. The trunnion ring is heated to redness and dropped over the breech coil, and, whilst the former is still hot, the muzzle coil is dropped through its upper portion, which was left projecting. The trunnion ring on cooling contracts, and grips the two coils together. The whole mass is then heated, and more securely welded together under a steam hammer. (Fig. 4.)

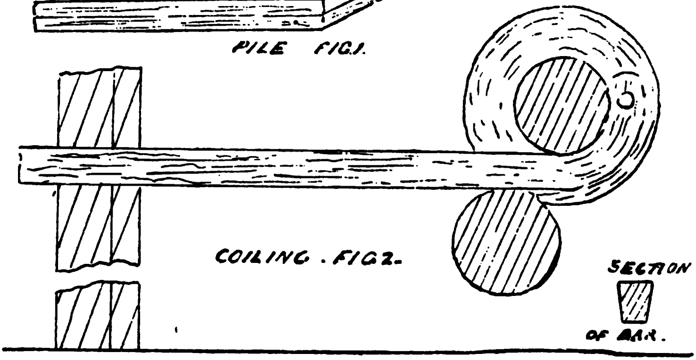
Trunnion Ring.—A cascable screw and trunnion ring are both solid forgings. The latter is made of slabs of iron consecutively welded together on the flattened end of a porter bar, and gradually formed into a ring by means of taper mandrils, increasing in size, driven through the centre. The trunnions are roughly hammered into shape, one of them being in continuation of the porter bar. The ring is then cut off from the bar, and roughly bored out. (Fig. 5.)

Building up a 10-inch gun.—The 10-inch gun, taken as an example, is then built up, and the parts shrunk together, in the following manner: the steel barrel is placed upright in a pit, muzzle end down, and a coiled breech piece, previously heated over a wood fire until sufficiently expanded to drop easily over the tube, is raised by a crane and dropped over it (Plate III. Fig. 1). During the shrinking a stream of cold water is poured into the steel barrel to keep it as cool as possible. On cooling, the coil, which dropped easily over the tube, fits tightly, and compresses the tube, remaining itself in a slight state of tension.

Shrinkage is equal to the compression plus the extension, and,

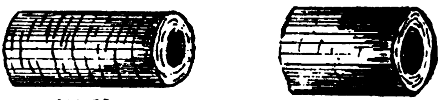
PL II.

PILE FIG. 1.



COILING. FIG 2.

FIG 3.



COILED. WELDED.

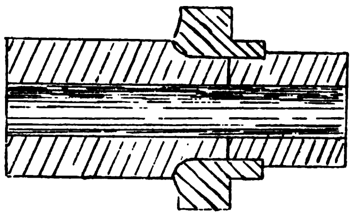
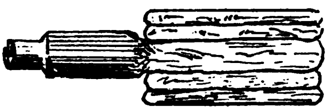
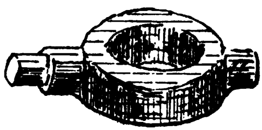


FIG 4.
JACKET
READY FOR
WELDING.



TRUNNION RING.



F. G 5.

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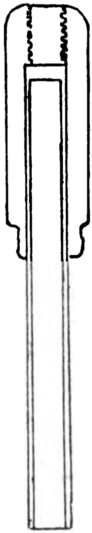
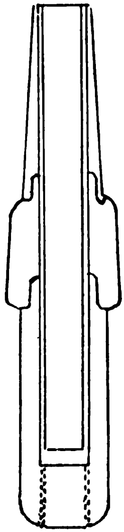
PL III.

FIG. 1.



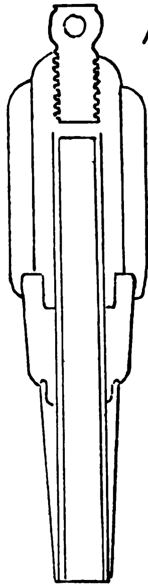
A TUBE & COILED BREECH PIECE.

FIG. 2



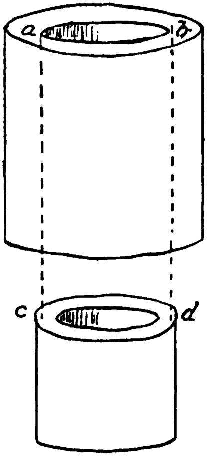
A & B LAYERS

FIG. 3



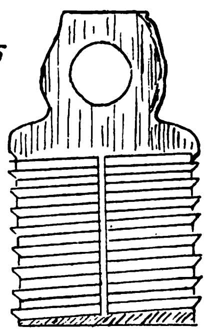
GUN COMPLETE.

FIG. 4.



SHRINKAGE

FIG. 5



CASCABLE SCREW.

[To face p. 7.

in shrinking any coils or tubes together, the inside diameter *a b* of the outer tube when cold is slightly smaller than the outside diameter *c d* of the inner tube (Fig. 4).

The A tube is then inverted, and No. 1 B coil shrunk on, and afterwards the B tube (Fig. 2). During the process of shrinking on the latter a ring of gas is placed round the muzzle or thin end to prevent its cooling prematurely, while a jet of cold water plays on the other end, which it is desirable should grip first.

The half finished gun, composed of the A tube and the B layer, is then rifled and the cascable screwed in. Great care is necessary in the latter operation to insure its having a fair bearing against the solid end of the steel tube, for the support of the latter, which object is further obtained by cutting a shoulder on the outside of the tube, which abuts against the breech piece, and helps to distribute the longitudinal strain over the latter as well as on the cascable screw. One round of the screw thread of the cascable next to the steel tube is turned off, in order that there may be an annular space there, which, together with a channel cut across the other threads, forms a gas escape to give warning in the event of the steel tube splitting (Fig. 5).

The gun is then completed by shrinking on the C coil, or jacket (Fig. 3), this operation having been delayed in order that the gun, being lighter, may be more conveniently moved from one position to another for the carrying out of the different machine operations, which are as follows :—

a. Centering, i. e. obtaining the axis of the solid or hollow cylinder before placing it on the lathe.
b. Turning or cutting off the exterior surface.
c. Boring out the inside of a cylinder, either hollow or solid.
d. Slotting or planing the exterior surface which cannot be turned.
e. Broaching to make the boring truly cylindrical.
f. Lapping, or rubbing down the bore with lead and emery powder and oil, to make it true to gauge.
g. Rifling, which is done in an ingenious horizontal machine, made suitable to any desired twist by inclining the copying bar to any angle; one groove only is cut at a time by the cutter on coming out.

Manufacture of R.M.L. guns generally.—In the manufacture of 9-inch guns, No. 1 B coil is omitted, and, below 9-inch, the coiled breech piece as well. The 9, 13, 16, and 25-prs. are composed of a jacket and steel tube only; the 40-pr. is exceptional, having a jacket, No. 1 B coil, and B tube.

80-ton gun.—The 16-inch of 80 tons differs from the 10-inch

in having in addition No. 2 B coil shrunk on between 1 B coil and the B tube, on account of the great length of the gun (Plate IV. Fig. 1).

100-*ton gun.*—The 17·72-inch gun of 100 tons, of which there are four in the Service, was built at Elswick, and consists of an A tube of tough steel in two parts, with a steel ring in halves over the joint, and a series of sixteen wrought-iron coils and a trunnion ring shrunk on successively; a forged wrought-iron block is screwed in at the breech to support the end of the A tube. (Plate IV. Fig. 2.)

6·6-inch *gun.*—The 6·6-inch gun is also exceptional, consisting of an A tube of steel, over which are shrunk a breech piece, B tube, C coil, and D coil. Over the breech piece and rear end of C coil is shrunk a jacket, or D coil, of wrought iron, having a forged trunnion ring welded thereto.

7-*pr. of* 400 *lbs.*—The 7-pr. R.M.L. jointed gun of 400 lbs. is made of steel. The gun consists of two parts—the breech portion and the muzzle portion. The breech portion is arranged to take the charge and projectile, and is formed out of a solid block of steel. The front end is screwed to receive the junction nut or trunnion ring; the muzzle portion consists of two parts—a steel chase and a wrought-iron trunnion piece.

The chase has a muzzle swell for strength. The two parts of the gun are united by means of the junction nut or trunnion piece and the screw on the breech, in conjunction with a spigot and faucet joint. A gas ring is introduced at the joint to prevent any escape of gas. A feather on the muzzle portion agrees with a recess in the breech, insuring the two parts coming together, and the union of the two parts is effected by screwing up the trunnion piece (Plate V. Figs. 1 and 2).

Proof.—Every gun is proved by firing one round with battering charge (heavy guns only) and two rounds with proof charges, which are always less than 1¼ the highest Service charge and the Service weight of projectiles. The gun is vented before proof with a removable vent in order not to injure the Service one. After proof, a water-test is applied, and guttapercha impressions of the interior of the bore are taken; the gun is also lapped to remove any burrs.

Preponderance.—The preponderance or excess of weight in rear of the trunnions is measured, which, for heavy guns is considered nil if under 3 cwt.

Weight.—The weight is ascertained, but in the case of heavy guns the different parts are weighed before being shrunk together.

Drilling for Sights.—The holes for the sights are drilled, and for this operation the gun is inclined at the required angle, the borer

PL. IV.

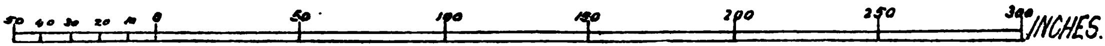
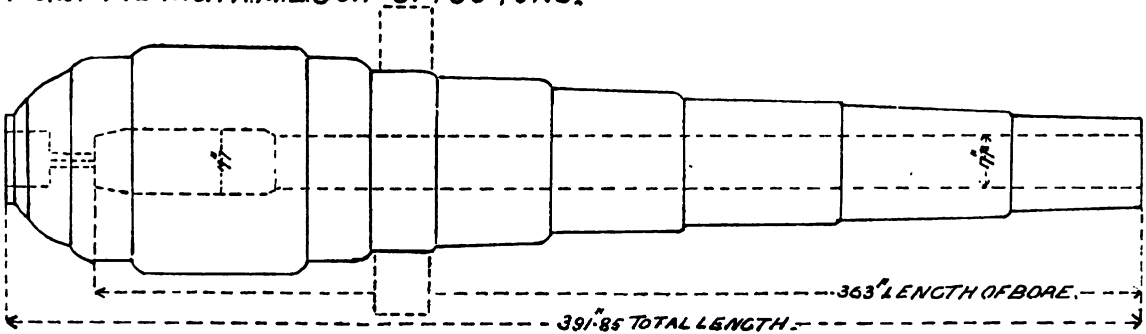


FIG. 2. 17·72-INCH R.M.L. GUN OF 100 TONS.



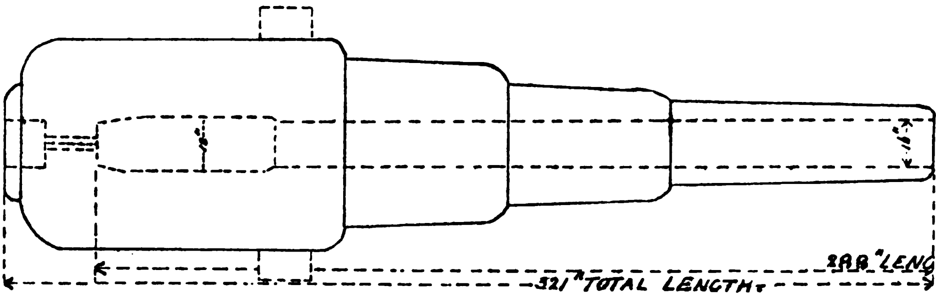


FIG. 1. 16-INCH R.M.L. GUN OF 80 TONS.

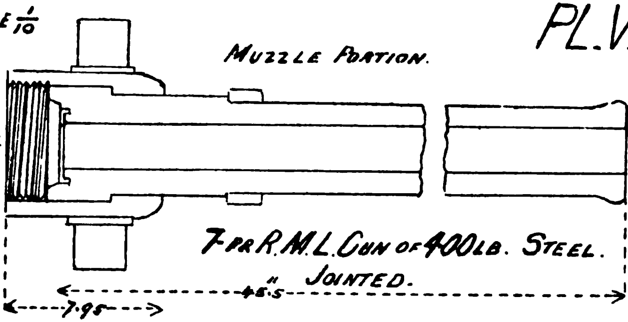
[To face p. 8.

SCALE $\frac{1}{10}$

PL. V.

MUZZLE PORTION.

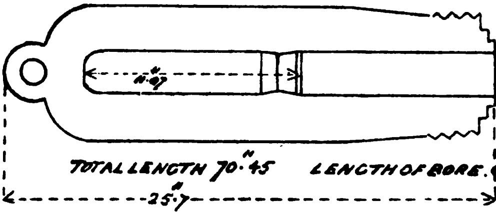
FIG. 1.



7-pr R.M.L. GUN OF 400 LB. STEEL.
" JOINTED.

BREECH PORTION.

FIG. 2.



TOTAL LENGTH 70"·45   LENGTH OF BORE. 66"·5.

POLYGROOVE RIFLING, PLAIN SECTION, 16-INCH R.M.L.
FULL SIZE.

FIG. 3.

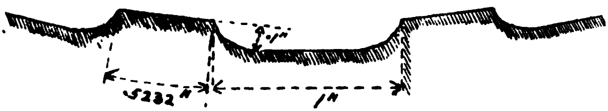
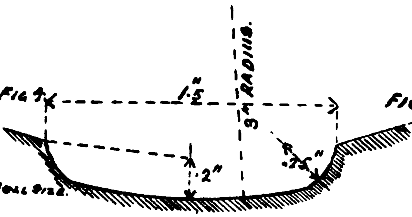


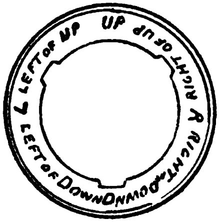
FIG. 4.



FULL SIZE.

WOOLWICH GROOVE.
10-INCH R.M.L. GUN.

FIG. 5.



POSITION OF FLAWS

[*To face p.* 8.

being vertical; the sights will then be set in at an angle which is always to the left, and is necessary in rifled guns to counteract "drift" or the tendency the projectile has to deviate to the right owing to the right-handed twist of the rifling; the angle of inclination, which varies for each nature of gun, and is found by actual practice, is marked on the breech.

Marks on Gun.—The Broad Arrow, Royal Cypher, and Weight are marked in front of the vent, and two parallel lines in the vent field denoting the end of the bore and the end of the rifling. Lines on the top of the gun are marked for the centre of gravity and half weight mark, which is the same distance as the cascable from the centre of gravity of the gun.

A line in the same vertical plane as the axis of the piece, and termed the line of metal, is marked on the breech; and vertical and horizontal lines are marked on the right trunnion and on the face of the muzzle.

On the left trunnion are marked R.G.F., or the factory where the gun was made; also its register number; a numeral signifying its mark or pattern; and the year of proof.

Rifling of R.M.L. Built-up Guns.

Rifling.—In the case of R.M.L. guns; in order to cause the elongated projectile to rotate round its longer axis, grooves are cut in the bore, along which move either studs attached to the projectile, or copper gas-checks adhering to its base and expanded on discharge into the grooves.

The velocity of rotation of the projectile depends therefore on the amount of twist given to the grooves in the gun, and on the velocity with which it passes through the bore.

The twist may be either "uniform" or "increasing," i.e. when the groove is laid out it will appear to be either a straight line as *a b*, or a curved line as *c d*.

The object of the introduction of the increasing twist originally was to reduce the strain on the studs and on the bore of the gun, at the moment of discharge, by allowing the projectile to move easily at first, its velocity of rotation gradually increasing as it passed through the bore.

The R.M.L. guns for the most part fire projectiles with studs which move along grooves that are few in number, varying with the different natures of gun.

These grooves have a uniform twist in 7-inch guns and under, and an increasing spiral in guns above 7-inch.

The amount of twist is reckoned by the length in calibres in which the projectile or groove makes one complete turn; thus the groove of the 10-inch 18-ton gun has an increasing twist of 1 in 100 to 1 in 40 calibres.

Section of Grooves.—In 25-pr. guns and upwards, except 64-pr. and polygrooved guns, the Woolwich groove is used (Plate V. Fig. 4). The bottom of the groove is eccentric to the bore, and its width and depth vary with the nature of the gun; the width is 1·5 inch for 7-inch guns and upwards, the bottom of the groove being struck with a radius of 3 inches for those guns. The French modified groove is used with the 9 and 16-prs.; the French groove with the 7-pr., and the plain groove with the 64-pr. guns: but the system is the same in all, the section of the grooves only varying.

In 10-inch guns and upwards, the loading side of the groove, that is the side against which the stud bears in loading, is cut away at the muzzle, and in the most recent patterns of those guns, the bore is slightly enlarged at the muzzle for facilities of loading.

The grooves in R.M.L. guns terminate at the powder chamber in order not to weaken the gun at that part, and also to insure the cartridge always occupying the same cubical space. 9-inch to 12·5-inch (mark I.) R.M.L. guns can be used either with studded projectiles or with studless projectiles having rotating gas-checks.

Polygrooved R.M.L. Guns.—The following R.M.L. guns are rifled on the polygrooved system, rotation to the projectile being given by means of a gas-check, which on discharge becomes firmly attached to the base and is expanded into the grooves, viz. 7-pr. 400 lbs., 13-pr. guns, 6·3-inch, 6·6-inch, 8-inch howitzers, 6·6-inch, 12·5-inch (II.), 16-inch, 17·72 inch guns. These guns have a larger number of shallower grooves than those rifled on the studs and grooves system; consequently by the polygrooved system, the gun is weakened less, and the strain is more evenly distributed circumferentially over the bore, also the projectile is not weakened by having studs pressed into it. (Plate V. Fig. 2.)

CHAMBERING.

The latest patterns of R.M.L. guns that were made were chambered, the diameter of the powder chamber being made larger than the bore in order to give air-space to the cartridge, by which means the strain on the bore of the gun at that part was greatly

decreased, consequently a larger charge could be used and a higher muzzle velocity obtained.

The 17·72-inch gun of	100	tons has a	powder	chamber	19·7	inch diam.
„ 16-inch gun of	80	„	„	„	18	„
„ 12·5-inch (II.) of	38	„	„	„	14	„

the length of the chamber being about three times its diameter. (Plate IV.)

Sights for R.M.L. Built-up Guns.

Sights.—All R.M.L guns from the 64-pr. of 64 cwt. and upwards have six sights, viz. two tangent or side sights, one centre hind sight, and three fore or trunnion sights.

The 16, 25, and 40-pr. guns are side-sighted, only having therefore four sights.

The 7, 9, and 13-pr. guns are central-sighted, having two sights only.

The hind sights of all, whether side or central, are set in at an angle to the left to counteract "drift" or constant deflection of a projectile to the right, due to the rotation imparted to it.

Side Sights.—The tangent or side sights consist of a rectangular steel bar with a gun-metal head in which slides a gun-metal leaf, which is used for giving deflection right or left in minutes, and is clamped by a screw in the required position. In the newest sights the deflection leaf is graduated to 50 minutes R. and L. of zero in the case of 64-pr. 64-cwt. guns up to 9-inch; in 9-inch guns to 45 minutes; 10-inch, 11-inch, 12-inch guns to 40 minutes. The notch in the deflection leaf is made 0·15 inch deep for heavy guns, and 0·06 inch for siege and field guns.

All siege and field guns having side sights, have a slow motion screw for giving minutes of elevation up to 10.

The graduations on the several faces of the bar differ in the several guns, and also in the various marks or patterns. There is 1. a scale of degrees marked on the front face of all, a degree on any tangent scale being 1-360th part of a circle which has for its centre the fore sight, and for its radius the distance between the fore sight and hind sight; this radius, therefore, varying for each nature of gun, and so the length of a degree marked on the scale.

In the case of heavy guns the three other sides of the bar are marked as follows: 2. a yards and fuze scale for common shell and full charge; 3. a yards scale for Palliser shell with battering charge; 4. a yards and fuze scale for common shell with battering charge.

Centre Hind Sights.—Centre hind sights for central-sighted guns, i. e. 7, 9, and 13-pr., also consist of a rectangular steel bar.

The centre hind sight for 8-inch guns and below is hexagonal and of gun-metal with a plain head, and is for use only at short ranges; 9-inch guns and upwards have the same lengthened and fitted with a sliding leaf for deflection. The letter D stamped in front of the socket denotes that the slot has been deepened to receive the lengthened centre hind sight, as all had formerly the short centre hind sight without a deflection leaf.

In the 12-inch 35-ton gun and 12·5-inch of 38 tons, the centre hind sights are precisely similar to their side sights.

Fore Sights.—The fore sights of the field guns are screwed in: in all other R.M.L. guns a fore sight of the "drop" pattern is used. The drop sight consists of a pillar and collar of gun-metal, a small steel leaf, and screw for fixing it; there is a socket of gun-metal in the gun into which the sight is secured by means of a double bayonet joint. To remove the sight the collar must be raised and the pillar then moved round a quarter of a circle.

Chase Sights.—Chase sights are used occasionally with guns above 25 tons, when the port would be liable to foul ordinary sights. The fore and hind sight are placed 30 inches apart on the chase, and the hind sight is provided with a movable mirror. The number laying the gun stands with his back to the port and in front of the trunnions, and lays until the object, the fore sight, and the notch of the hind sight are reflected in line in the mirror.

French's Sights for Siege-train Ordnance.—The 25-pr. and 40-pr. guns, and the 6·6 inch and 8 inch of 70 cwt. howitzers, are provided with French's sights, which can be used either for direct or reverse laying. The tangent scales are set vertically, and have bronze heads with clamping screws, each having a steel horizontal cross-bar. This bar slides within the head to the extent of 1° right and 3° left for giving deflection. The bar is provided with a sliding reversible leaf, having a notch for direct laying. For reverse laying the leaf has a pointed sight and cross wires for rough and fine laying. The bar is graduated from 0° to 8° right for the right sight, and the same left for the left sight of the gun or howitzer.

The trunnion sight consists of a steel stem, with a horizontal cross-bar, forged solid and graduated from 0° to 8°, to correspond with the tangent sight. The bar is fitted with a reversible sliding leaf, having a point for direct laying, and a notch and telescopic hole for rough and fine laying in reverse. For direct laying the method is the same as for service sights, except that both sliding leaves must be clamped at corresponding divisions of the respective cross-bars, so as to obtain a line parallel to the axis of the piece, any deflection required being given on the part of the bar specially graduated for the purpose.

For reverse laying, the line of fire is obtained, and the piece laid by the clinometer for the first round. Before firing an aiming point is selected in rear, in prolongation of the line joining the sights, the leaves of which can be clamped in any position on the cross-bars, and likewise the tangent scale raised to any height. For each succeeding round the gun is laid on the aiming point, any alteration required in elevation or deflection being made in the usual way.

Wheel guides screwed on to the platform insure the gun always being run up into the same position. For night firing a lantern would be used as an aiming point.

Sights for 6·6-*inch gun.*—The 6·6-inch gun, mounted on a disappearing carriage, is provided with two sets of sights, one set of reflecting sights and one of the ordinary Service pattern.

Sights for 13-*pounder.*—The 13-pr. sights can be used for rough or fine laying; for the latter there is a hole under the notch of the hind sight, which is used in conjunction with cross wires below the apex of the fore sight, which is a roughened acorn sight.

Sights for 16-*inch and* 17·72-*inch guns.*—The 16-inch gun of 80 tons is not furnished with sights, the turrets in which the guns are mounted being sighted. Chase sights are provided for exceptional use.

The 17·72 inch gun of 100 tons has two rows of reflecting sights, one on each side.

Moncrieff Sights.—For guns mounted on Moncrieff carriages special sights are provided, consisting of two mirrors, one being secured to the right trunnion, the other slides along the graduated bar fixed at the lower end of the elevator. The gun is laid by bringing the reflection of the object and the cross lines of the upper mirror on to the cross lines of the lower. The elevation of the gun is governed by the position of the lower mirror upon the graduated bar.

Clamps for sights.—Movable clamps of gun-metal are used to clamp the side sights of 25-pr. R.M.L. guns and upwards at the required elevation, thus enabling the sight to be adjusted out of the gun.

Clinometer.—Watkin's clinometer can be used for giving to guns or howitzers the necessary elevation. This instrument, like the quadrant, only gives angles of elevation or depression with reference to the horizontal plane; therefore, the angle of elevation or depression from the gun to the object must be known and added to or subtracted from the angle given by the tangent scale or range table.

Index Plate and Reader.—For 9-inch guns and upwards, mounted in casemates, index plates and readers are provided. The index plate of gun-metal is secured one on each side of the breech, and

is graduated for 10° of elevation and 6° of depression. The "reader," a gun-metal pointer, is secured to the carriage, so that the numbers working the elevating gear can see when the required elevation is given.

FITTINGS OF R.M.L. GUNS.

Muzzle Derrick.—A muzzle derrick is fitted to 9-inch guns and upwards when mounted in open batteries, for the purpose of raising the projectile up to the muzzle. It consists of a band fixed round the chase near the muzzle by screws; to this the derrick is secured. At its upper end there is a loop, into which is hooked the upper block of the loading tackle. The derrick is supported by a bridge piece on the chase, so that it projects over the muzzle at a convenient angle for loading.

Elevating Plates.—Metal elevating plates connect the gun to the elevating racks on the carriage. They are attached to the gun by screws. In field guns the elevating screw is attached to the gun by a bolt passing through the elevating eye.

All fittings are attached to a gun by screws, and when the fittings are removed the screw holes are filled up by preserving screws.

Trunnion Studs for 38-ton guns.—Trunnion studs are screwed into the trunnions of 38-ton guns for facilities in mounting and dismounting them by means of the box beam apparatus.

VENTS OF R.M.L. GUNS.

Vents.—The hole bored into a gun for the purpose of communicating the flash of the tube to the cartridge is termed the vent or vent channel. As the rush of powder gas through this hole would wear away the metal of the gun, a vent bush of hardened copper is screwed in, which can be renewed at any time. There are two kinds of copper vents or bushes, the "through" and the "cone" vent.

The former is a cylinder with a square head, by which it is screwed into the gun, and has a screw thread cut down its whole length.

In a "cone" vent the screw thread terminates near the end, and the cylinder merges into the frustum of a cone.

New guns are vented with a cone vent, and a through vent is afterwards inserted when in order to remove flaws it is necessary to bore out the cone part of the metal of the gun.

The position of the vent may be axial, i.e. when the vent runs through the axis of the breech, or it may strike the powder chamber at an angle or perpendicularly to the axis, and either near the bottom of the bore or more forward.

Radial or Forward Vents.—In 64-pr. R.M.L. built-up guns and upwards (except axially vented guns) the vent strikes the bore vertically at a distance of 4-10ths of the length of the cartridge from the rear. This position was originally found to give the best results as regards muzzle velocity and strain on the bore.

In 10-inch guns and upwards, on account of the size of the breech, the vent is inclined at an angle of 45° to the perpendicular, coming out at the side instead of the top of the gun.

In 40-pr. guns and under the vent strikes the bore close to the end, this being especially necessary when firing with reduced charges: the 13-pr. vent, however, is 7 inches from the end.

In R.M.L. howitzers having chambers, the vents are inclined at an angle so as to strike the conical chamber at right angles and near the end of the bore; in the 8-inch of 70 cwt. and 6·6-inch of 36 cwt. howitzers the vents are vertical, as these howitzers have no chambers.

The vent channel has a diameter of 2-9ths of an inch, that of the tube being 2-10ths of an inch.

Axial Vents.—The following R.M.L. guns are axially vented: 12·5-inch of 38 tons (mark II.); 16-inch of 80 tons; 17·72-inch of 100 tons. They have steel removable vents prepared for gas sealing tubes, and are provided with a safety shutter. The vent consists of a steel bolt containing the vent channel, one end is mushroom-shaped, the other is fitted with a cross-handled removable head prepared to receive the vent sealing tube either electric or frictional.

The shutter is employed to guard against accidents arising from defective tubes and for security in case the head of the vent should not be properly screwed up.

Designation of R.M.L. Guns.

Designation.—Guns of 6·6-inch calibre and upwards are designated by their calibre and weight: below that by the weight of the projectile they fire and the weight of the piece. Howitzers are always known by their calibre and weight.

Examination of R.M.L. Ordnance.

Examination.—A memorandum of examination or register sheet accompanies every rifled gun: in it are recorded the material of the bore, a description of the construction, and a diagram showing the gun in section: any defects at the time of its issue are noted, also the number of rounds it has fired, and any subsequent examinations.

It is directed that 9-inch guns and upwards are to be examined

after every 50 rounds: 64-pr. to 9-inch after every 100: below 64-pr. after 150 rounds. Before being examined the bore must be thoroughly cleansed, if necessary by firing one or two scaling charges, i.e. a charge one-third of the Service charge without a projectile. Any new defects, and also any old ones that have materially increased, are taken notice of, and gutta-percha impressions are made.

The position of any flaw is measured by its distance from the muzzle in inches, and is noted as "up," "right of up," &c., as the case may be (Plate V. Fig. 5).

Longitudinal cracks are occasionally found in steel tubes, which it is most important to note; as a rule, defects are rare in steel tubes, but when they do exist are of serious moment.

Impressions of the bottom of the vent must also be taken. "Chokes" may occur in the vent channel, which must be removed by a rimer.

The vent channel may be gradually increased by an irregular wearing away of the bottom, and fissures or hair-lines are found radiating into the metal of the bore from the edge of the vent bush. If these lines extend 1 inch from the edge of the bush or 0·5 inch if directly to the front or rear, the gun would be provisionally condemned.

With regard to the exterior, the outer coils on firing occasionally shift. Defective welds near the muzzle are of no importance.

Classification of R.M.L. Ordnance.

R.M.L. guns in the Service are used as follows, and may be classed accordingly:—

Class 1.—For mountain batteries, 7-prs. of 400 lbs. and 7-prs. of 150 and 200 lbs.

Class 2.—For Field and Horse Artillery batteries, 9-prs. of 6 or 8 cwt., 13-pr. of 8 cwt., 16-pr. of 12 cwt.

Class 3.—Siege train ordnance consist of

Nature of Ordnance.		Number in Divisions.		
		Light.	Medium.	Heavy.
R.M.L. Guns	25-pr. of 18 cwt.	8	..	..
	40-pr. of 35 cwt.	..	6	4
	6·6-inch of 70 cwt.	..	..	2
R.M.L. Howitzers	6·3-inch of 18 cwt.	8	..	..
	6·6-inch of 36 cwt.	..	10	..
	8-inch of 70 cwt.	..	..	10
No. of pieces in each division		16	16	16

A siege-train will consist of any number of divisions, Heavy, Medium, or Light, according to the requirements of the service. A Heavy Division will be composed of powerful and accurate pieces, such as would preferably be employed against important fortresses, unless insuperable difficulties in the way of transport intervene to prevent the use of such heavy metal.

A Medium Division will be composed of pieces of medium weight, for use when difficulties of transport prevent the employment of heavier metal.

A Light Division will be composed of the lightest siege-pieces, for employment when, owing to the difficulties of the country or to the necessity for promptness of action, great mobility might be essential.

Class 4.—Medium guns, for land fronts of fortresses, and for sea-fronts for use against wooden shipping, 64-pr. of 64 cwt., 7-inch of 90 cwt., and the three natures of converted guns, viz. 64-pr. of 58 and 71 cwt., and 80-pr. of 5 tons.

Class 5.—Heavy guns for land and sea-service, for use against armour-plated vessels or fortresses.

The following belong to this class:—

7-inch of 6½ and 7 tons.
8-inch of 9 tons (sea service only).
9-inch of 12 tons.
10-inch of 18 tons.
11-inch of 25 tons.
12-inch of 25 and 35 tons.
12½-inch of 38 tons (I. and II).
16-inch of 80 tons.
17·72 inch of 100 tons (land service only).

In most of these guns there are several marks or patterns—in guns below 9-inch the various marks only differ in the manner in which the B layer of metal is put on.

TABLE I.

List of Rifled Muzzle-Loading Ordnance.

Guns.	Mark.	Material.		Total Length in Inches.	Rifling.			Vent Position in Inches from End of Bore.	Muzzle Velocity in Feet per Second.	Length of Bore in Inches.	Penetration of Wrought-Iron Armour Plate.	
		Exterior.	Tube.		System.	Twist in Calibres.	Number of Grooves.				At 1000 Yards.	At 2000 Yards.
											ins.	ins.
7-pr. of 150 lbs.	III.	Steel	..	29·1	French	U, 1 in 20	3	1·0	673	24·0		
" 200 "	IV.	"	..	41·0	"	" "	3	1·0	968	36·0		
" " "	II.	Bronze	..	38·125	"	" "	3	1·0	914	32·1		
" 400 "	I.	Steel	..	70·45	Polygroove (plain section)	I, from 1 in 80 at breech to 1 in 30 at 3·53 ins. from muzzle, remr. U, 1 in 30	8	5·25	1440	66·5		
9-pr. of 6 cwt.	II.&III.	Wt. iron	Steel	74·5	French modified	U, 1 in 30	3	0·6	1390	66·0		
" "	I.	"	"	61·0	" "	" "	3	0·6	1234	53·0		
" 8 cwt.	I. & II.	"	"	72·0	" "	" "	3	0·6	1380	63·5		
13-pr. of 8 cwt.	I.	"	"	92·1	Polygroove (plain section)	I, from 1 in 100 to 1 in 30 at 9 ins. from muzzle, remr. U 1, in 30	10	7·0	1560	84·0		
16-pr. of 12 cwt.	"	"	"	78·0	French modified	U, 1 in 30	3	0·6	1355	68·4		
25-pr. of 18 "	"	"	"	98·0	Woolwich	" 35	3	1·0	1320	88·0		
40-pr. of 34 "	"	"	"	100·5	"	" "	3	0·6	1310	85.5		
" 35 "	II.	"	"	120 0	"	" "	3	7·0	1380	104·5		
64-pr. of 58 "	I.	Cast iron	Wt. iron	127·45	Plain groove	" 40	3	1·8	1245	108·45		
" 71 "	"	"	"	122·72	"	" "	3	1·8	1230	103·27		

„ 64 „	III.	Wt. iron	Steel	118·0	„	„ „	3	5·2	1285 and 1383	97·5		
„ „ „	I. & II.	„	Wt. iron or Steel	120·0	„	„ „	3	5·2	1170	98·0		
80-pr. of 5 tons	I.	Cast iron	Wt. iron	136·55	Woolwich	„ „	3	1·85	1240	113·25		
6·6-in. of 70 cwt.	„	Wt. iron	Steel	118·0	Polygroove (plainsection)	I, 1 in 100 to 1 in 35 at 2 cals. from muzzle, remr. U 1 in 35	20	5·2	1468	97·5		
7-in. of 90 cwt.	„	„	„	131·0	Woolwich	U, 1 in 35	3	8·6	1361	111·0		
7-in. of 6½ tons	III.	„	„	133·0	„	„ „	3	8·6	1525	111·0	7·2	5·9
7-in. of 7 „	IV.	„	„	148·0	„	„ „	3	8·6	1540	126·0	7·2	5·9
8-in. of 9 „	III.	„	„	144·0	„	I, 0 to 1 in 40	4	9·2	1413	118·0	8·3	7·0
9-in. of 12 „	V.	„	„	156·0	„	„ „ 45	6	9·7	1420	125·0	10·2	8·7
10-in. of 18 „	II.	„	„	180·0	„	I, 1 in 100 to 1 in 40	7	11·0	1364	145·5	12·2	10·9
11-in. of 25 „	„	„	„	180·0	„	I, 0 to 1 in 35	9	10·0	1315	145·0	13·4	12·0
12-in. of 25 „	„	„	„	182·0	„	I, 1 in 100 to 1 in 50	9	9·8	1300	145·0	13·30	12·0
12-in. of 35 „	I.	„	„	195·0	„	I, 0 to 1 in 35	9	12·0	1300	162·5	14·9	13·5
12·5-in. of 38 „	„	„	„	230·0	„	„ „	9	12·0	1445	198·0	16·1	14·8
„ „	II.	„	„	230·0	Polygroove (plain section)	I, 1 in 438 to 1 in 35		Axial	1546	198·0	17·1	15·8
16-in. of 80 „	I.	„	„	321·0	„	I, 0 to 1 in 50	33	„	1604	288·0	23·3	21·7
17·72-in. of 100 tons	I.	„	„	391·8	„	I, 1 in 105 to 1 in 50 at 2·88 ins. from muzzle, remr. U, 1 in 50	28	„	1548	363·0	22·8	21·0
Howitzers.												
6·3-in., 18 cwt.	„	„	„	56·0	„	I, 1 in 100 to 1 in 35	20	1·125	778	45·0		
6·6-in., 36 „	„	„	„	90·7	„	I, 1 in 94 to 1 in 35	20	1·5	839	79·2		
8-in., 46 cwt.	„	„	„	64·0	Woolwich	U, 1 in 16	4	1·75	697	48 0		
„ 70 „	„	„	„	113·0	Polygroove (plainsection)	I, 1 in 90 to 1 in 35	24	2·0	950	96·0		

CHAPTER III.

R.M.L. CONVERTED GUNS—OLD PATTERN R.B.L. GUNS—SMOOTH-BORE ORDNANCE.

R.M.L. Converted Guns.

Natures.—The following smooth-bore guns have been converted into rifled guns, viz.:—

32-pr. S.B. of 58 cwt. into 64-pr. R.M.L. of 58 cwt.
8-inch shell gun of 65 cwt. into 64-pr. R.M.L. of 71 cwt.
68-pr. of 95 cwt. into 80-pr. R.M.L. of 5 tons.

Process of Conversion.

The Palliser principle is employed, which consists in boring out the old cast-iron gun, and inserting a wrought-iron tube into the casing.

The method of conversion is the same in all cases, and, taking the 32-pr. of 58 cwt. as an example, is as follows:—

The cast-iron gun is bored out from 6·29 to 10·5 inches, and the muzzle is recessed and threaded for the cast-iron collar which keeps the tube in position. The tube is formed of five wrought-iron coils joined longitudinally together, the bars from which they are made being passed three times through the rolling mill.

The breech end of the tube is closed by a wrought-iron cup screwed into it, the cup being made of a solid forging. The tube is then proved with a water pressure of 120 lbs. on the square inch.

The outside of the breech end of the tube is turned down for a length of 32 inches, and has cut on it a spiral gas channel, which communicates with star grooves cut in the end of the barrel, and with the gas escape through the breech.

The B tube, consisting of two coils united, is shrunk on over this portion of the A tube, the latter being thus made double at that part both for additional strength, and also to enable any gas to escape through the gas channel without bursting the gun in the event of the tube failing.

The whole tube is then oiled and fitted into the casing; the curved part of the end of the barrel is described with a longer radius than the corresponding curve in the interior casing, to prevent the tube acting as a wedge to split open the cast-iron.

PL.VI.

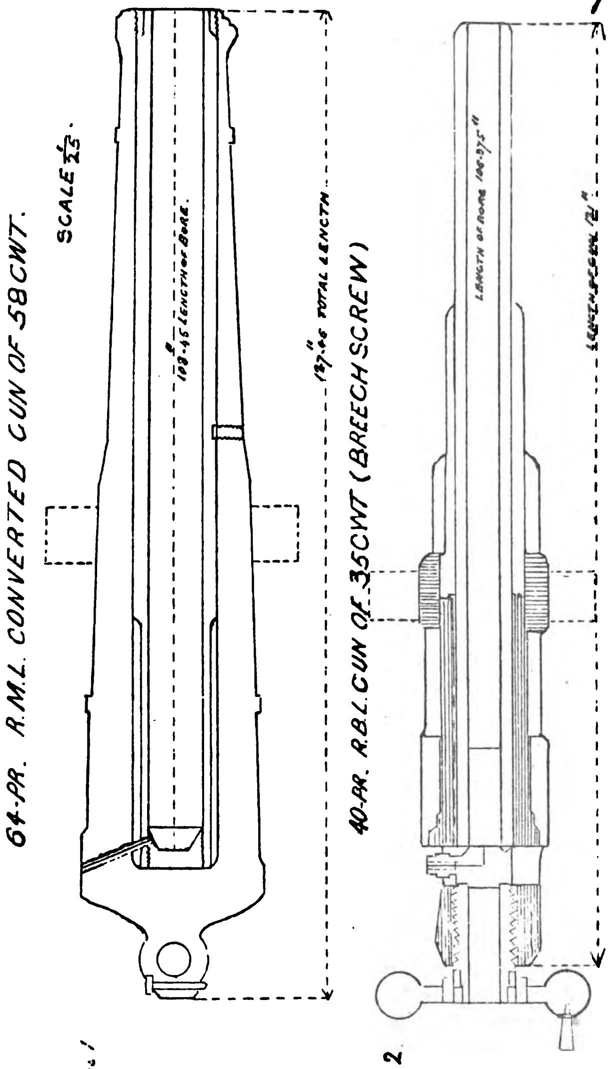


FIG 1

FIG 2

[To face p. 20.

The cast-iron collar is then screwed in at the muzzle, over a shoulder on the tube, and a wrought-iron pin is screwed through the cast-iron casing into the tube, under the gun, and in front of the trunnions, to prevent the tube shifting round (Plate VI. Fig. 1).

The gun is then rifled, the groove for the 64-pr. guns being the "plain groove," and for the 80-pr. the Woolwich groove as for built-up guns. Three grooves are used in all cases, the twist of rifling being uniform, and 1 in 40 calibres. The plain groove is the narrow deep portion of the groove of the 64-pr. (shunt gun) now obsolete; it is used with all 64-pr. guns, in order that the same ammunition may suit all natures. The bottom of the groove of the 64-pr. is 0·6 inch wide and struck with a radius of 3·26 inches.

Converted guns are "through" vented with a copper bush, the old vent of the S.B. gun being used, which has an inclination of about 10°, except in the case of the 64-pr. (8-inch), when the old vent is plugged up and a new one bored.

After proof the tube becomes permanently expanded, and fits the casing tightly; should it fail it requires forcing out by hydraulic pressure.

The diameter of the bore, after proof, of all the converted guns is 6·3 inches.

Sights of Converted Guns.

Sights.—The 64-pr. (58-cwt.) is central-sighted, and has three sights. The centre hind sight is of gun-metal and hexagonal in section; it is graduated to 12° on the front face, corresponding to 4000 yards. There is a yards scale on the rear face, and a fuze scale on the right rear face. It has the ordinary sliding leaf for giving deflection up to 90′ right and left, each division representing 10′. The centre fore sight is of the usual drop-sight pattern, the socket into which it fits being fixed in a bracket attached to the gun. It is used in conjunction with the hind sight for angles of elevation up to 5°, i.e. the clearance angle of the gun.

The muzzle sight is recessed into the dispart patch on the muzzle, and is used in conjunction with the hind sight for angles of elevation over 5°, when the centre fore sight becomes fouled by the muzzle.

Consequently the degrees on the hind sight above 5°, corresponding to the long radius, are longer than those under 5°, which correspond to the short radius.

The divisions on the deflection leaf correspond to the short radius, and more deflection would be given, therefore, when using the muzzle fore sight.

The old pattern centre hind sight has no deflection leaf, and is only graduated up to 5°, corresponding to 2000 yards; and there is no muzzle fore sight in those guns having the old sights. The slot for the hind sight in the gun requires deepening for the employment of the new sights.

The 64-pr. (71 cwt.) and 80-pr. guns are side-sighted, having four sights, the tangent sights being of the ordinary pattern as used with built-up guns. They have the slow motion elevating nut for giving elevation up to 10′, and are provided with movable clamps.

The hind sights of 64-pr. converted guns are set at an angle of 2° 16′ to the left, those for the 80-pr. at an angle of 19′.

Examination of Converted Guns.

Examination.—Converted guns are examined after every 150 rounds. Impressions are taken of the whole of the powder chamber, showing also the joint where the cup closes the end of the bore. Imperfections of welds will always exist in the wrought-iron barrels, but as a rule they are of little consequence unless found to increase as the gun is used. A defective weld running right round the bore would be of serious moment; but otherwise the depth of the defect is of more importance than its extent.

Old Pattern R.B.L. Guns.

Construction of Old Pattern R.B.L. Guns.

Construction.—The R.B.L. guns formerly introduced were all built up on Armstrong's original construction, and the greater portion are entirely of wrought iron, a few only having steel tubes.

Many still exist in the service, and consist of a wrought-iron inner or A tube, a B tube, a forged trunnion ring, forged breech-piece, and one or more coils, according to the nature of gun.

The natures made were 6, 9, 12, 20, and 40 pounders and the 7-inch gun.

The method of construction is as follows:—

The inner or A tube is made of wrought-iron coils united together longitudinally. The trunnion ring and breech-piece are forged, and the gun is built up by shrinking on the parts over the wrought-iron barrel. A slot is cut on the top of the breech for the vent-piece, and a circular hole is drilled underneath it; the end of the breech-piece is threaded for the breech screw (Plate VI. Fig. 2).

The diameter of the powder chamber is larger than that of the shot chamber, and immediately in front of the latter is the "grip," which is the smallest part of the bore.

From the grip to the muzzle the bore is slightly enlarged, in order to ease the projectile as it passes through the bore; there are thus four different diameters, the calibre of the gun being measured at the grip, which in the 40-pr. is 4·75 inches, 20-pr. 3·75 inches, 12-pr. and 9-pr. 3 inches, 6-pr. 2·5 inches.

Breech Fittings.

Vent-piece.—The vent-piece is the block that closes the breech end of the bore; through it passes the vent in a vertical direction down the neck to the axis of the piece, and thence in the direction of the axis. A portion of the vertical part only is bushed with copper, to avoid weakening the vent-piece. The material of which the latter is made is marked on the back; wrought-iron, steel, Swedish iron, steel toughened in oil, and, latterly, Marshall's refined iron have been used.

A vent-piece consists of a body, vent bush of copper in two parts, copper ring, cross head, and shackles or handles. Those for the 40-pr. and 7-inch guns have two handles; lower natures one. The former have a beak, to prevent the face being injured when the vent-piece is placed in the slot. There is a projection on the back of every vent-piece, and those of old pattern without it should on no account be used at practice.

In vent-pieces of the 40-pr. and lower natures a copper ring is forced into an annular undercut groove on the face. This must be kept properly faced, and any burrs removed with a file. This copper ring insures a gas-tight joint when fitted against the breech bush of copper, which is screwed into the end of the bore. The two surfaces of copper are coned in opposite directions, and consequently can be pressed tightly together. 7-inch guns have no copper ring or breech bush of copper, but a tin cup is used to effect a gas-tight joint. 40-pr. and 7-inch vent-pieces are laid on the top of the breech when out of the slot; in the lower natures they are removed from the gun when the breech is opened.

Breech screw.—The breech screw is of steel, except for the 7-inch gun, in which case it is of wrought-iron faced with steel. A screw thread is cut on the outside of it, which fits rather loosely the screw thread in the breech. The breech screw, being firmly screwed up against the back of the vent-piece, retains the latter in its position.

Tappet ring.—The tappet ring is octagonal in shape on the

inside, fitting on to a similar octagon on the outside of the breech screw; it thus acts as a wrench to screw or unscrew the breech screw. It has cams or projections on it by which power is communicated to it from the lever, which also has corresponding projections.

Lever.—The lever fits on to the breech screw behind the tappet ring; it can revolve freely round it, and is prevented from falling off by two keep pins working in a cannelure.

Levers of 20-pr. and lower natures have one handle, one weight ball or accumulator, and one projection to act on the cams of the tappet ring; 40-prs. have one handle, two weight balls, and two projections; 7-inch levers have two of each.

Indicator ring.—The indicator ring is used with 40-pr. and 7-inch guns, and is a thin narrow ring of wrought-iron fitted on to the breech screw in front of the tappet ring. On its inner surface are a series of grooves, any of which fit a feather on the breech screw. When adjusted, and when the vent-piece is properly screwed up, the brass projections on the ring and on the top end of the breech-piece must coincide, or the former be slightly to the left, but never to the right.

Rifling of R.B.L. Guns.

Rifling.—The guns are rifled on the polygrooved system, the grooves having a uniform twist. The lands, or portions of the bore between the grooves, are made as narrow as possible, in order to cut well into the soft lead coating of the projectile, by which means rotation is given. The calibre of the gun is measured across the lands; the grip causes the projectile to be well compressed into the grooves before it moves.

Sights of R.B.L. Guns.

Sights.—The guns are side-sighted, and of the ordinary pattern, except the tangent sights of the 7-inch, of 72 cwt., and 12-pr., which are hexagonal and of gun-metal, being those first made. Some of the older pattern sights are barrel headed, in which case the deflection leaf is traversed right or left by means of a screw worked by mill-headed thumbscrews at each end of the barrel head; each revolution traverses the leaf 10′. They were discontinued owing to their liability to become unserviceable.

Fittings.—An iron lever, about 2 feet 10 inches long, is used for prizing out the vent-pieces of 7-inch guns when they jam. 7-inch guns are fitted with a metal saddle attached to the gun in rear of the vent slot to form a rest for the vent-piece when the breech is open.

Converted 35-cwt. 40-pr. R.B.L. Gun.

Converted 40-*pr.*—This gun has been altered so that the vent-piece slot is on the right side. The alteration is effected by heating the trunnion ring and turning it round a quarter of a circle to the left.

The gun is fitted with a breech block converted from the original vent-piece, the vent being plugged up. The block is supported by an upper and lower bracket, between which it slides; its movements in and out of the gun being limited by a spring stop worked by a small lever. The breech block is fitted with a copper ring. The gun has a radial vent on the right side, 6·5 inches from the end of the bore, inclined at an angle of 45° to the plane of axis of gun and trunnions.

Examination of R.B.L. Guns.

Examination.—7-inch guns are ordered to be examined after firing 100 rounds; 40-pr. and lower natures after 150 rounds. Impressions would only be taken when flaws were seen, and, as a rule, of the breech bush of the gun and of the face of the vent-piece. The face of the breech screw and the back of the vent-piece are examined with a straight-edge, as it is most important they should fit true to each other; particular attention should also be paid to the fitting and facing of the vent-piece copper ring, and breech bush.

Smooth-bore Ordnance.

Description.—Smooth-bore ordnance were made of cast-iron and bronze cast in moulds and afterwards bored out; their manufacture ceased in 1859.

Subsequently, however, a few 100 and 150-prs. S.B. guns of wrought iron and built up were made, but they are now obsolete.

S.B. ordnance, of which many still exist in the armament of fortresses in certain positions, consist of guns, carronades, howitzers, and mortars; the carronades are of cast-iron only.

Guns and carronades fire either shot or shell, howitzers and mortars only shell.

Position of Trunnions.—The axis of the trunnions of guns and howitzers is below that of the piece; the centre of gravity lies behind the trunnions, the excess of weight in rear of them being termed the "preponderance."

TABLE II.

List of Breech-loading Guns (Old Pattern).

Guns.	Mark.	Material.		Total Length.	Length of Bore.	Calibre.	Rifling.			Vent, Position in Inches from End of Bore.	Muzzle Velocity, Foot Seconds.
		Exterior.	Tube.				System.	Twist in Calibres.	Grooves (number).		
Old Pattern Armstrong Guns.				ins.	ins.						
6-pr. of 3 cwt.	..	Wt. iron	Wt. iron	60·125	53·0	2·5	Polygrooved	U, 1 in 30	32	Through vent-piece striking cartridge at centre of bore.	1046
9-pr. of 6 „	..	„	„	62	52·5	3·0	„	„ 38	38		1055
12-pr. of 8 „	..	„	„	72	61·375	3·0	„	„ „	38		1239
20-pr. of 13 „	..	„	Wt. iron or steel	66·125	54·125	3·75	„	„ „	44		1000
„ 15 „	..	„	„	66·125	54·125	3·75	„	„ „	44		
„ 16 „	..	„	Wt. iron	96	84·0	3·75	„	„ „	44		1130
40-pr. of 32 „	..	„	„	120	106·375	4·75	„	„ 36½	56		1180
„ 35 „	..	„	Wt. iron or steel	121	106·375	4·75	„	„ „	56		
7-in. of 72 „	..	„	Wt. iron	118	97·5	7·0	„	„ 37	76		1165
„ 82 „	..	„	„	120	99·5	7·0	„	„ „	76		

TABLE III.

List of Smooth-Bore Ordnance.

			Ordnance.						
			Weight.	Length.		Bore. Calibre.	Bore. Length.		Preponderance.
			cwt.	ft.	in.	in.	ft.	in.	cwt.
Bronze.	Guns.	12-pr. ..	18	6	6	4·623	6	2½	2·3
		9-pr. ..	13½	5	11·4	4·2	5	7·74	1·5
		6-pr. ..	6	5	0	3·668	4	9·47	0·75
	Howitzers.	32-pr. ..	17	5	3	6·3	5	1¼	2·0
		24-pr. ..	12½	4	8·6	5·72	4	7·15	1·0
		12-pr. ..	6½	3	9·2	4·58	3	7·8	0·5
		4⅖-in. ..	2½	1	10	4·52	1	8·86	0·5
	Mortars.	5½ in.-royal	1¼	1	3·1	5·62	0	11·94	..
		4⅖ in.-coehorn ..	¾	1	1	4·52	0	10¼	..
Cast-iron.	Carronade.	68-pr. ..	36	5	4	8·05	5	2	2·3
		42-pr. ..	22	4	5	6·84	4	7	1·0
		32-pr. ..	17	3	11·71	6·25	3	11¾	0·5
		24-pr. ..	13	3	8	5·68	3	7¼	0·3
	Guns.	68-pr. ..	112	10	10	8·12	10	3½	10·8
		,,	95	10	0	8·12	9	5·9	10·5
		10-in. ..	86	9	4	10·0	9	1·33	9·0
		8-in. ..	65	9	0	8·05	8	9·27	8·0
		42-pr. ..	84	10	0	6·97	9	6¾	9·0
		,,	67	9	6	6·935	9	0¾	9·0
		32-pr. ..	58	9	6	6·375	9	0·65	6·0
		,,	56	9	6	6·41	8	11·2	5·0
		,,	50	9	0	6·375	8	7·08	7·0
		24-pr ..	50	9	6	5·823	8	11·41	4·5
		18-pr. ..	42	9	0	5·292	8	5·75	3·5
		,,	38	8	0	5·292	7	6	3·5
		12-pr. ..	34	9	0	4·623	8	6¼	3·5
		9-pr. ..	28	8	6	4·2	8	0½	2·7
	Howitzers.	10-in. ..	42	5	0	10·0	4	9¼	5·0
		8-in. ..	22	4	0	8·0	3	9¾	2·5
	Mortars.	13-in. ..	100	4	5	13·0	3	3	
		,,	36	3	3·65	13·0	2	8·5	
		10-in. ..	52	3	10	10·0	2	11	
		,,	18	2	5	10·0	2	1	
		8-in. ..	9	2	1·23	8·0	1	8	

The trunnions of mortars, for convenience in high angle firing, are placed at the breech; carronades have in place of trunnions a protruding loop underneath, through which a bolt passes to attach the piece to the carriage.

Designation.—Guns and carronades are known by the weight of their projectile; shell guns, howitzers, and mortars by their calibre and weight.

Windage.—In S.B. ordnance a certain amount of "windage" or difference between the diameter of the projectile and the bore of the gun is necessary, in order to leave room for loading when the bore becomes fouled, and also on account of imperfections in casting.

Use.—32-prs. were formerly the principal armament, especially of war vessels; of these guns there were eleven natures, those weighing 56 and 58 cwt. being mostly used in fortresses and coast batteries.

The 68-pr. of 112 cwt. was the heaviest cast-iron gun made, but the 68-pr. weighing 95 cwt. is the most commonly met with.

The 8-inch shell gun of 65 cwt. was used as a siege train gun, and was also mounted in permanent works.

Mortars are short pieces of ordnance used for firing shells at high angles of elevation, usually 45°, the charge being altered to suit the range.

Howitzers are shorter and lighter than guns, and fire shells heavy in proportion to the weight of the piece with low charges.

Vents.—Cast-iron ordnance have the nature of vent marked on cascable, thus C V, N, C, denotes copper vent, new gun, cone vent; C V, C, copper vent, cone vent, not new gun; C V, through vent of copper.

Sights.—The sights used are known as Millar's sights, and consist of a fore or dispart sight screwed on in rear of the trunnions, and of a half-round brass tangent scale which slides in a block of gun-metal secured to the breech by two screws. The tangent scale is set at an angle of 76° to the front, in order to clear the breech. The distance between these sights is termed the short radius, and when the hind sight, the fore sight, and the notch on the muzzle are in line, the clearance angle is obtained; at angles of elevation above this the notch at the muzzle is used in conjunction with a wooden scale fitted on to the brass one, the distance between them being the long radius; the only scale marked on these sights is a degree scale.

Examination of S.B. Guns.—S.B. guns firing 10-lb. charges and upwards are examined after every 100 rounds, under 10-lb. charges after 200 rounds. It would only be necessary to take an impression of the vent and portion of the bore immediately

adjoining it. Defects would only be taken notice of if they were 0·1 inch deep in rear of the trunnions, and 0·2 inch in front; or if they have jagged edges likely to hold pieces of cartridge. On the exterior attention must be paid to the soundness of the trunnions and cascable loop.

Converted 32-pr. B.L. Gun of 42 cwt.

32-*pr.*—The 32-pr. of 42 cwt. has been converted into a B.L. gun for the purpose of being employed in the rapid firing of case shot in caponnières, flanks, &c.; the breech-closing arrangement is that employed with the new B.L. guns first made.

The system of obturation, or means of forming a gas-tight joint, consists of a steel cup attached to the breech screw as described for those guns.

These guns are used without tangent sights, but are supplied with a dispart sight.

CHAPTER IV.

NEW-TYPE BREECH-LOADING GUNS.

All ordnance now being constructed are breech-loaders. Not only has this change taken place, but the new-type guns also differ considerably in shape and appearance from the old-type R.M.L. guns, and in their construction and material; steel being entirely used. On account of the greater strength of tempered steel as compared with wrought iron, and from excessive chamber pressures being avoided by using very large grain powder of high density, the great thickness of metal at the breech end compared to that at the muzzle is no longer necessary: so that "in order to get an increased ratio of power to weight, thickness of metal at the breech is turned into length at the muzzle." *

Construction.—(*a*) A few of the earliest B.L. guns were made with steel inner tubes and wrought-iron coils shrunk over; then steel coils took the place of the wrought-iron ones: but in all those now made, forged steel hoops are used. The inner tube is made thin in order to avoid any imperfections in casting, and extends to the rear only sufficiently far to receive the obturator: over the tube is shrunk a breech-piece, which is supported by exterior hoops. By this construction the whole of the metal assists in bearing the transverse strain, but the breech-piece takes the longi-

* *Vide* a lecture given by Colonel Maitland, Superintendent R.G.F. at the R.U.S. Institution.

tudinal strain: * and the tube, which is subject to erosion and is thin, is thus relieved from the latter strain. The form given to the breech opening renders it easy to bore out the eroded surface after continued firing, and to insert a thin lining into the tube itself. The metal of the breech-piece is made thicker over the front threads of the breech block where the longitudinal strain acts most, than in the more forward parts of the chamber. The breech-piece is hooked to the B hoop in front of the trunnions by means of a key ring fitted on in halves (Plate VII. Fig. 3), over which is shrunk a small hoop: by this means the gun is prevented from being parted asunder by the longitudinal strain; there is further a shoulder formed on the A tube to prevent it from slipping forward. This construction is shown in Plate VII., in a section of the 6-inch B.L. gun, Mark III., which is an example of the method of construction of the latest marks of all the modern guns with certain modifications. In earlier patterns, the breech screw is made to engage in the inner tube itself, when the latter had to be made thicker.

In order to obtain longitudinal strength also in the guns most recently designed, the following method is employed by Colonel Maitland, the Superintendent of the Royal Gun Factories, who describes as follows the manner in which hoops which abut against one another endways are linked together by outer hoops:—"The exterior of the inner hoop carries a ring which is slotted away so as to leave alternate projections and intervals. The interior of the outer hoop carries a corresponding ring which is also slotted away so as to leave alternate projections and intervals. The outer hoop, expanded by heat, is passed over the inner hoop, so that the projections pass through the intervals, it is then turned so as to bring the projections of one hoop exactly in line with the projections of the other, thus preventing any longitudinal movement. The intervals are then filled up with long steel wedges, which are forcibly driven in. One wedge would be sufficient to prevent any circumferential shift, but all the intervals are filled up, so that the strain from the interior on firing is directly transmitted to the whole of the outer hoop. Half the metal of the layer represented by the thickness of the wedge is not available for resisting the transverse strain. This is made up by slightly increasing the thickness of the outer hoop. By this device the gun is stiffened at the joints, and held together longitudinally from the extreme breech end to a point far up the chase—an advantage in point of strength and safety possessed by no other design."

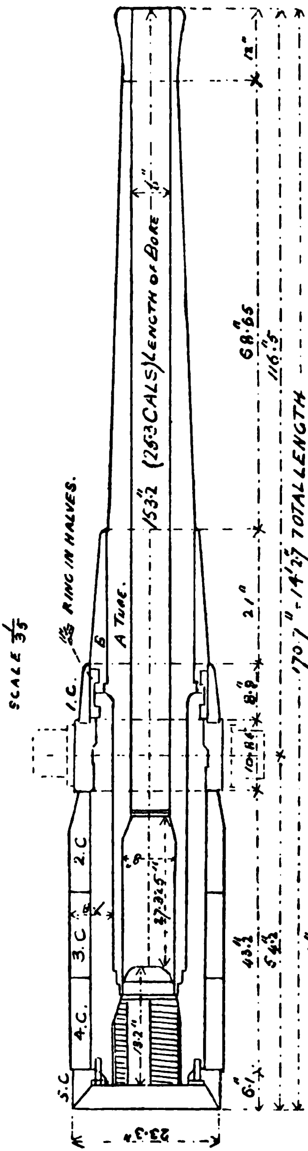
Breech Mechanism.—The breech-closing arrangement is the interrupted screw system. The breech is closed by a steel breech-screw having three or four longitudinal smooth surfaces, each $\frac{1}{6}$th or $\frac{1}{8}$th

* Almost entirely.

PL. VII.

6-INCH BREECH LOADING GUN OF 89 CWT. MARK III.

SCALE 1/35



SECTION OF GROOVE ·05" DEEP ·6" WIDE (24).

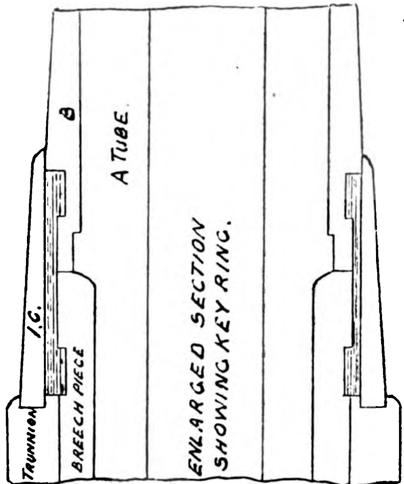


FIG 3. SCALE 1/10

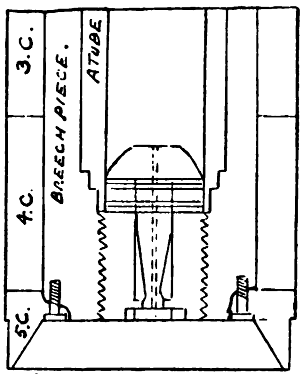


FIG 2. SCALE 1/10

DE BANGE OBTURATOR 6-IN OF 89 CWT.

[To face p. 30.

of the circumference, the remainder of the screw being left in relief; the interior of the breech being prepared in a similar manner.

Thus the raised portion of the thread of the breech screw coming opposite the relieved portion of the thread of the gun can be easily pushed home, and a small turn is sufficient to engage the threads and securely close the breech. On withdrawal the breech screw is received on to a carrier which revolves on a hinge pin and is held back by a retaining bracket when in a loading position: the action of the carrier by which it is secured to or released from the face of the breech is automatic.

Elswick System of Obturation.—A gas-tight joint is secured at the breech end of the bore in a few of the guns that were first constructed by means of a steel cup obturator, which is attached to the face of the breech screw: the back of the cup is flat, whilst the face of the breech screw is slightly rounded; on discharge the gas presses the cup back against the breech screw, driving its rim against a copper ring let into the walls of the bore. This cup and ring require frequent renewal, which is a work of some hours in the case of the ring, and requires very skilful mechanics.

De Bange Obturator.—This system of sealing all escape of gas is now entirely employed. A stem or stalk passes lengthways through the breech screw, and has on the end towards the bore a steel mushroom-shaped head. Round the stalk and between the breech screw and mushroom there is a collar or pad of asbestos secured in a canvas cover, and on either side of the pad is a disc of white metal having a ring or edge of phosphor bronze.* On firing, the mushroom head is pressed back against the asbestos collar and the latter is squeezed against the walls of the bore and prevents any escape of gas. Being soft, it readily accommodates itself to any irregularity caused by grit, &c. The parts can be easily renewed when necessary. (Fig. 2.)

Vents.—The vent channel passes through the stem and head of the de Bange obturator, and on the rear end of the stem there is a clutch box which carries a percussion lock for firing percussion vent-sealing tubes: safety arrangements are provided.

In the case of the 6-inch Mark II. there is a removable vent-head carrying a vent-sealing tube. Field guns are vented with a steel removable bush, to take the ordinary friction tube.

Rifling.—The system of rifling is polygroove, the section of groove being hook-shaped, and known as the M.B. or Maitland breech-loading type. The depth varies from ·04 to ·06 of an inch; the non-driving side being sloped off to the surface of the bore. The grooves have an increasing twist for a certain length and the remaining portion to the muzzle is uniform.

* Latterly steel rings.

Rotation is given to the projectile by the driving or rotating ring of soft metal attached to it which is compressed into the grooves.

Chambering.—In all the B.L. guns the powder chamber is made larger in diameter than the bore of the gun in order to keep down the length of the cartridge, and also to retain as great a length of bore as possible for useful effect. The length of the chamber is from 3 to 3½ diameters, and the curve where it joins the bore is made as gradual as possible.

Manufacturing Operations.

A Tube or Barrel.—To manufacture a steel tube an ingot of cast steel is fixed to an ingot holder at the end of a porter bar, and then heated and drawn out under the hammer until it is roughly of the length and shape required; density and uniformity are thus given to the casting by the forging operation.

In the case of a small tube it is bored out, but the larger ones are trepanned, i. e. the inside is cut out solid; and the core may be used for a smaller tube.

The tubes terminate in a swell at the muzzle in order to give strength, and are made as thin as possible at the breech end, in conjunction with strength, in order to obviate risks of imperfections in the casting.

Breech-pieces and Hoops.—The breech-pieces are made from castings well forged under the steam hammer, and trepanned out: they are turned and bored to finished dimensions and shrunk on in the ordinary way.

The hoops which form the outer layers are sometimes rolled on a roll or mandril in place of being forged, after having been cut out of cylindrical ingots in a cheese-shaped form.

Jackets for the smaller natures of guns, 5-inch and under, are forged in one piece out of ingots, the trunnions and rough shape being formed under the hammer and the mass trepanned out.

The tubes, breech-pieces, &c., are tempered by being heated and plunged in oil.

Natures of B.L. Guns.

The following are, or will be, the natures of B.L. guns in the service:—

12-*pr. of* 7 *cwt.*—Composed of a steel tube, jacket of steel locked round, and small hoop to cover the wedges and hood; calibre 3 inches, length of bore 84 inches. The vent is radial and made of

steel, being removable. The de Bange system of obturation is used. Muzzle velocity, 1700 f. s.; charge, 4 lbs. P. powder.

22-*pr. of* 12 *cwt.*—Similar construction, with a bore 28 calibres in length and diameter of 3·5 inches. Muzzle velocity, 1760 f. s., and charge, 7·5 P.

4-*inch of* 13 *cwt.*—Of wrought iron and steel. Steel cup and copper ring system of obturation. Vent is a copper bush screwed in. Charge, 3¼ $R.L.G._2$ powder; projectile, 25 lbs.; muzzle velocity, 1180 f. s.

4-*inch of* 22 *cwt.* (Mark I.).—Of wrought iron and steel, with a radial steel removable vent. Charge, 13 lbs. P. powder; projectile, 25 lbs.; muzzle velocity, 1930 f. s.

4-*inch of* 22 *cwt.* (Mark II.).—Composed of A tube and six hoops, de Bange obturator and axial vent, vent-masking slide and hood for vent-sealing tubes.

4-*inch of* 22 *cwt.* (Mark III.).—Breech screw gearing into breech-piece, key ring in halves, small hoop over key ring. De Bange obturator with axial steel vent and percussion lock.

5-*inch of* 36 *cwt.* (Mark I.).—A tube and six hoops of steel.

5-*inch of* 36 *cwt.* (Mark II.).—A tube jacket, key ring in halves, small hoop breech screw gearing into the jacket. Muzzle velocity, 1800 f. s.; charge, 16 lbs. P. powder; projectile, 50 lbs.

6-*inch of* 80 *cwt.* (80-*pr.*).—Wrought iron and steel. Cup and ring system of obturation. Muzzle velocity, 1881 f. s.; charge, 34 lbs. P. powder. E.O.C. construction.

6-*inch of* 81 *cwt.* (II.).—Steel and wrought iron. Charge, 34 lbs. P_2; projectile, 100 lbs.; muzzle velocity, 1660 f. s.

6-*inch of* 89 *cwt.* (III.).—Of steel: consisting of barrel, breech-piece to take the breech screw, B hoop, key ring in halves, small hoop over key ring, trunnion hoop, C_1, C_2, C_3, and hood. Muzzle velocity, 1950 f. s.; charge, 42 lbs. P_2 powder; weight of projectile, 100 lbs. (Pl. VII.)

8-*inch of* 11 *tons* (Marks I. and II.).—Of steel. Steel coils are used in place of hoops.

8-*inch of* 12 *tons* (Marks III. and IV.).—Steel barrel, breech-piece and hoops, key ring in halves. Charge, 100 lbs. of $Prism_1$ powder; projectile, 210 lbs.

9·2-*inch of* 18 *tons* (Marks I. and II.).—Steel and wrought-iron coils are both used.

9·2-*inch of* 19 *tons* (Mark III.).—Steel hoops and breech-piece; outer tubes are locked and wedged in position. Length of bore is 31·5 calibres; the diameter of the powder chamber 12·5 inches and its length 41 inches. Muzzle velocity, 2030 f. s.; charge, 200 lbs. C_2; projectile, 380 lbs. about.

10-*inch of* 26 *tons* (Mark I.).—Of similar construction. Muzzle

velocity, 2100 f. s.; charge, 300 lbs. C_2; projectile, 500 lbs. (probably).

12-*inch of* 43 *tons* (Mark I.).—Composed of steel and wrought iron; it has three steel coils. Length of bore about 25 calibres.

Mark II., of similar construction. Mark III., E.O.C. construction. Mark IV., of recent construction. Muzzle velocity, 2100 f. s.

13·5-*inch of* 63 *tons and* 16¼-*inch of* 110 *tons.*—These guns are under construction for the Navy.

PART II.

AMMUNITION.

CHAPTER V.

GUNPOWDER, CARTRIDGES, ETC.

Gunpowder.

Composition.—English gunpowder, as manufactured at Waltham Abbey, is an intimate mechanical mixture of 75 parts of saltpetre, 15 of charcoal, and 10 of sulphur.

The saltpetre or nitrate of potash is obtained in its natural state in hot climates, and can be also produced artificially; it acts as a magazine of oxygen (for the powder) with which it parts when raised to a certain temperature; the oxygen then combining with the carbon in the powder to form carbonic acid and oxide, which together with free nitrogen form the chief gases of the combustion of powder.

Charcoal is the residue which remains after the liquid and other volatile parts have been driven out of wood by charring it. Dogwood, willow, and alder are the woods chiefly employed in the manufacture of charcoal for powder.

The more perfectly the wood is charred, the more moisture is expelled, and the density and incombustibility of the charcoal is then greater; if imperfectly charred, the charcoal so obtained is softer and more inflammable, and makes a violent powder, which absorbs moisture easily and is liable to deteriorate.

Sulphur is found in an uncombined state in volcanic districts, and also occurs combined with iron, copper, and other metals: owing to its great inflammability it facilitates the ignition of powder, and from its non-absorbent properties renders the powder less liable to deteriorate from the absorption of moisture, and more compact and durable.

Advantages.—Gunpowder explodes when raised to a temperature of 600° Fahr.; its chief advantages, beyond that possessed by other explosives, are, that it is comparatively safe in manufacture,

store and transport, and that its rate of burning can be regulated. Also the ingredients of which it is made are easily obtained.

In its manufacture, the description of charcoal used and the incorporating or thorough mixing of the ingredients are the most important considerations.

The explosiveness of powder, i. e. the rate at which it burns, depends principally on the density and size of the grain, and to a lesser extent on the shape, hardness, and amount of glaze imparted to each grain.

Density and Size of Grain, &c.—The denser the grain, i. e. the more powder contained in a grain of given size, the slower it will burn; and as regards size of grain, an ounce of powder, say of 10 grains or pieces, will burn quicker than the same quantity made up of 5 grains; there being in the first case a larger amount of surface of ignition.

The greater the interstices between the grains in a charge of powder, the quicker will be the ignition of the whole charge: so that a charge may have a high rate of ignition, but a slow rate of combustion.

Therefore a charge for heavy guns which is required to burn slowly in order to give time for the projectile to move, before the whole of the gas is evolved, and then to be pushed as it were through the bore, is made up of large grains of high density forming a slow-burning powder, whilst the larger interstices facilitate its ignition: so that each grain should be ignited almost simultaneously, but owing to the size and density of the grain, the combustion of the whole charge will be gradual.

The proportion that the length of a charge bears to its diameter is of great importance. If a length of about 3½ diameters is exceeded, what is termed "wave" action is set up, and abnormal strains in the powder chamber are produced.

As regards shape of grain, in order to secure a uniform amount of strain in the bore, the grains should each be similar in shape and size: hence prismatic and cylindrical powders have been introduced, taking the place of pebble powder in which the grains are irregular cubes of sizes varying between certain limits.

The first-named powders have axial perforations in each grain, by which means the interior of the grain is ignited as well as the exterior. For use in small arms and with lighter pieces of ordnance firing low charges, a quicker burning powder made up of smaller grains is required: hence different natures of powder are necessary to suit all classes of ordnance and small arms.

PL.VIII.

C² Powder.

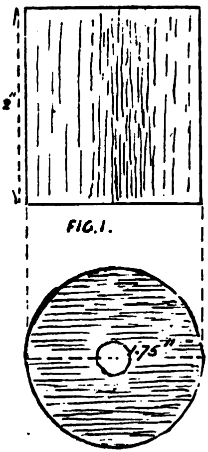


FIG. 1.

SCALE $\frac{1}{2}$

Prism² Powder.

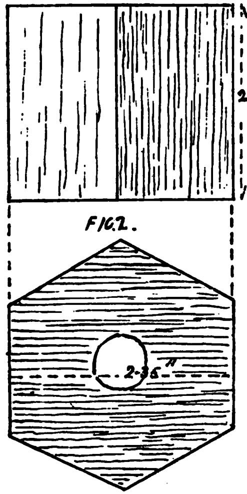
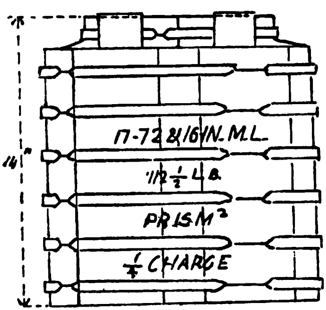
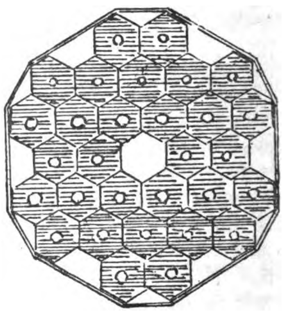


FIG. 2.

FIG. 3.

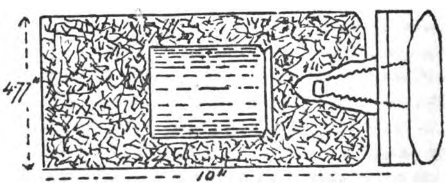


$\frac{1}{10}$



CARTRIDGE OF PRISM² POWDER.

FIG. 4.



40-PR R.B.L CARTRIDGE.

[To face p. 37.

NATURES OF GUNPOWDER.

The following are the "natures" of powder in use in the service:

Pistol Powder.—Made like F.G. powder, or obtained from the siftings of R.F.G.$_2$

F.G. Powder.—Fine grain. Is not now made, but the stock is used up for bursting charges of shrapnel shell and for S.B. small arms.

R.F.G. Powder.—Rifle fine grain. Size 12 to 20 mesh, that is, the grains pass through a sieve having between 144 and 400 holes to the square inch; density about 1·6; it is used for rifled small arms except Martini-Henry, for 7-pr. of 200 lbs., and for bursting charges of shrapnel shell.

R.F.G.$_2$ Powder.—Size 12 to 20 mesh; density 1·72 to 1·75; used for Martini-Henry rifles and Gatling guns.

L.G. Powder.—Large grain. Is not now made, but stock may be used up in place of R.L.G. with Service charges of guns up to 9-inch, except 7-pr. (400 lbs.) and 13-pr.

R.L.G. Powder.—Rifle large grain. 4 to 8 mesh; density 1·68; may be used for all full charges of guns up to 12-inch (except 7-pr. (400 lbs.) and 13-pr.) and with howitzers, and also in place of P. powder for battering charges up to 12-inch.

R.L.G.$_2$ Powder.—3 to 6 mesh; density 1·66; used with 7-pr. (400 lbs.) and 13-pr. and howitzers, and may be used with guns up to 64-pr., 64 cwt.

Pebble Powder.—P. Size about $\frac{5}{8}$th inch cubes; density 1·75; the grains have rounded edges and run about 80 to the lb.; used for battering charges up to 12-inch inclusive, and for full charges from 80-pr. to 12-inch inclusive.

P$_2$ Powder.—Size 1½-inch cubes; density 1·75; 5 to 7 grains to the lb.; used with 12-inch and 12·5-inch (mark I.) guns.

Prism.$_1$ Powder.—Prismatic. Made from grain pressed into hexagonal prisms of height 0·976 inch and diameter over sides 1·367 inch; axial perforation 0·394 inch diameter; density 1·75; used with 80 and 100-ton R.M.L. guns.

Prism.$_2$ Powder.—Made from grain pressed into hexagonal prisms of height about 2 inches and diameter over sides of 2·35 inches; axial perforation of each grain ·575 inch diameter; density 1·75; used with 38-ton, 80-ton, and 100-ton R.M.L. guns. (Plate VIII. Fig. 2.)

M.G.$_1$ Powder.—Size 7 to 14 mesh; has been introduced for Nordenfelt machine guns.

C^2 Gunpowder is for use with 9·2-inch B.L. guns and upwards: the powder is in the form of cylinders of height 2 inches and

diameter 1·75 inch. Each cylinder has an axial perforation ·25 inch in diameter. The density of the powder is 1·83 (Fig. 1).

In the case of the new B.L. guns, considerable pressure is required before the projectile moves, owing to the rotating ring being slightly larger than the bore, hence a very slow-burning powder can be used with advantage; the length of bore of these guns enabling the whole of the powder to be profitably consumed.

Classes of Gunpowder.

Gunpowder is further divided into classes according to its condition.

Class I.—Service powder; used for cartridges, and consisting of all new powder and returned powder found uninjured.

Class II.—Blank powder; used for blank cartridges, and consisting of powder from broken-up cartridges (except B.L. small arms), and returned powder found unfit for Class I.

Class III.—Shell powder; used for filling shell, and consisting of powder found too dusty or broken in grain for Class II.

The above three classes are termed "serviceable powders."

Class IV.—Doubtful; consisting of all powder returned to store and awaiting examination.

Class V.—Condemned for sale; powder found unfit for any of the first three classes.

Class VI.—Condemned for extraction of saltpetre; consisting of powder fit for no other purpose, and of all powder emptied from shells or from cartridges containing their own means of ignition.

Cannon powders are proved for muzzle velocity and pressure in the bore of a gun: about 20 tons on the square inch is the maximum pressure allowed.

Mealed powder passes through an 120-mesh sieve; it is ordinary powder reduced to an impalpable dust; it ignites easily, and burns rapidly, and is used in quick match, portfire composition, friction tubes, &c.

Pit mealed powder is so called on account of the charcoal having been prepared in pits in place of cylinders. It is used in fuze composition, on account of its regularity of burning.

Gun-cotton.

Gun-cotton is produced by the action of nitric acid and sulphuric acid on pure cotton, when a chemical change takes place.

It is used in the Service in a compressed state in the form of discs or slabs weighing from 1 oz. to 2½ lbs., and in the form of yarn as a primer for wood time fuzes when firing with small charges.

It can be manufactured, stored, transported, and exploded in a wet condition; a wood case containing from 50 to 60 lbs. being used for the stowage and transport of wet gun-cotton.

When in a wet condition, compressed gun-cotton is uninflammable, but can be detonated by using a primer of dry gun-cotton; the latter can be detonated in an unconfined state by using a detonator containing fulminate of mercury: for the latter purpose, holes are bored in the primers of dry gun-cotton to receive the detonator.

Gun-cotton is used in the Service for destroying bridges, lines of railway, stockades, &c., and also for rendering an enemy's guns unserviceable. It is issued for these purposes to cavalry, horse artillery, and siege-train artillery. It is used extensively in torpedoes.

Detonating Compositions.

Chlorate of potash has the property of detonating on being rubbed or struck, when mixed with sulphur or sulphide of antimony: it is found in all detonating compositions, except when fulminate of mercury is used alone. The latter is prepared by the action of alcohol on a solution of mercury in nitric acid. It detonates with great violence on being rubbed or struck.

Cartridges.

Material.—The material of which a cartridge bag is made must be strong enough to stand the wear and tear of travelling, and a reasonable amount of knocking about when filled.

It must be permeable to the flash of the tube, and yet of sufficiently close texture to prevent any dust working its way through; also the material should be entirely consumed, or at any rate leave no smouldering fragments in the bore of a gun.

All cartridge bags are made of serge or silk cloth, except the 4-oz. charge of 7-pr. R.M.L. guns, which is contained in a red shalloon bag; these materials fulfil the above conditions.

Serge cartridges are used for S.B. ordnance, except when firing blank; and for the old pattern R.B.L. guns, except the 40-pr.

Silk cloth is used for all other cartridges, this material being stronger than serge and less likely to smoulder: there are three classes of silk cloth of different strengths, the cartridges of the heavier natures of guns being required to be made of stouter material.

Making up Cartridges.—Cartridges are filled by weighing out the requisite amount of powder; the mouth being closed by choking and the shape preserved by hooping with braid or silk twist.

They are marked with the nature of gun and the weight of their contents in black printers' ink which will not hold fire like paint.

Their length is gauged by means of the universal cartridge gauge, their diameter by brass ring gauges.

They are issued empty for artillery service except for field and siege artillery.

S.B. Cartridges.—Cartridges for S.B. ordnance are made conical for gomer chambered pieces, viz. 8 and 10-inch shell guns, howitzers and mortars, and cylindrical for other natures.

R.M.L. Cartridges.—Cartridges for R.M.L. ordnance are made cylindrical or slightly coned for heavy guns; and in two pieces, one rectangular, the other circular: those for R.M.L. converted guns are cut in one piece.

For 7-inch R.M.L. guns and upwards there are two classes of Service cartridge, "battering" and "full." The former charge is used with Palliser projectiles, and also for all other projectiles when engaging an enemy. The full charge is used with common and shrapnel shell and case shot under ordinary circumstances.

A becket or handle is used with 20-lb charges and upwards for convenience of handling.

The cartridge for the 12·5-inch R.M.L. gun (Mark I.) of 38 tons is of No. 2 class silk cloth, made up in two half charges, each containing 80 lbs. of P_2 powder for the battering charge. A wooden stick $1\frac{1}{2}$ inch in diameter is placed down the centre, and choked by the cartridge round a groove at either end. Its use is to insure the charge occupying a uniform space when the projectile is rammed against it.

Cartridges for 12·5-inch (Mark II.), 16-inch and 17·72-inch R.M.L. guns are made up in four quarter charges for battering charges: for full charges a wooden wad is used in place of the fourth cartridge. The cartridges have no choke, the top and bottom ends being sewn to the sides and made to the shape necessary to fit over the prisms of powder as they may be built up.

A hole four inches in diameter, and filled in with an open network of silk twist, is made in the centre of the silk cloth at both ends to facilitate the ignition of the powder from the flash of the tube, as well as to communicate from one cartridge or quarter charge to another: each cartridge has two beckets: the holes are covered with discs of shalloon to protect the powder in store, which are removed before loading. (Plate VIII. Fig. 3.)

R.B.L. Cartridges.—Cartridges for old pattern R.B.L. guns are of serge, except for the 40-pr. which is of silk cloth. A lubricator is either inserted in these cartridges or is screwed into a wooden socket which is choked into the cartridge.

The lubricator consists of two thin tinned iron cups soldered

together, and containing a mixture of tallow and linseed oil, attached to a felt wad and backed by millboard; the wad is coated with beeswax. Its object is to prevent the grooves of the gun from being choked with the lead which is apt to strip off the projectiles.

A varnished paper cylinder is placed in the centre of the 7-inch 40-pr. and 20-pr. R.B.L. cartridges in order to bring them up to the length of the powder chamber. (Plate VIII. Fig. 4.)

Cartridge for 6-inch B.L. gun of 80 *and* 81 *cwt.*—The battering charge for the 80-cwt. gun is made up in one cartridge, which is fitted with a hollow tube of thin wood and brown paper, about half the length of the cartridge: the front end of this tube is closed by a wooden cone perforated with three small holes: a small puff containing 1 oz. of F.G. powder is inserted in the tube: the rear end of the tube is riveted to a zinc cone round which the bag is choked. The full charge is a cartridge of ordinary pattern.

The cartridge for the 81-cwt. gun is made up in two cartridges, each containing 17 lbs. of P_2 powder for the battering charge.

Drill Cartridges.—Drill cartridges are brought up to the size and weight of the Service cartridges they represent by having cast iron in the centre of a wood block covered with leather or canvas.

Cases and Barrels used for Filled Cartridges and Gunpowder.

Metal-lined Cases.—Metal-lined cases are of deal, rectangular in shape, and lined with tinned copper. They are used in magazines that are not very dry and in the siege train for containing filled cartridges. They are in sizes, whole, half, or quarter. The whole case will contain all cartridges for S.B. ordnance and for rifled ordnance up to the 9-inch gun.

Gun-ammunition Barrels.—Gun-ammunition barrels are used in dry magazines to contain cartridges: the lid has a circular opening: they are in two sizes, whole and half.

Zinc Cylinders.—Zinc cylinders are used to contain the cartridges of heavy ordnance. They each contain one cartridge * and act as cases in the magazine, and also serve to bring the cartridge up to the gun. There are separate cylinders for the full and battering charge. Those for the 11, 12, and 12·5-inch are not to be stacked more than three deep, 9 and 10-inch four deep, 7-inch five deep.

Cartridge-cylinder Bearers.—A wood cartridge cylinder bearer is issued for all zinc cylinders: it is 3 ft. 6 in. long, 1 in. thick, 2¼ in. in the centre, and tapered off towards the ends.

* The 7-inch cylinder will contain two 14-lb. cartridges or one battering charge.

Gun-metal Cages.—Gun-metal cages are used for hoisting zinc cylinders containing cartridges up the powder lifts of magazines; a 2-inch white rope with a hook at one end and ball at the other being used with them.

Powder Barrels.—Powder barrels are used to contain loose powder, and are of three sizes, whole, half, and quarter, containing respectively 100 lbs., 50 lbs., and 25 lbs. The whole barrel will contain 125 lbs. of P. or P_2 powder and 120 lbs. of R.L.G.$_2$ on account of their greater density. They are made of Quebec oak and fitted with copper and ash hoops. Powder barrels with metal lids are now made, to prevent the necessity of heading and unheading.

Wood Powder-cases.—Wood powder-cases are used in carrying and storing prismatic or cylindrical powder not made up into cartridges. Each case will contain 100 lbs. of prismatic or cylindrical powder. The case is lined with zinc, and painted red inside and out.

Transit of Powder by Rail.—When loose powder is sent by rail, it is contained in a flannel bag, and placed in a half or quarter-barrel; the barrel being covered with canvas and placed in an iron case or cylinder.

Budge Barrels.—Budge barrels are used for holding loose powder for mortars; they have only one head, the other being replaced by a leather bag, the mouth of which is closed by a leather thong.

Paper Covers.—Paper cartridge-covers are used to cover cannon cartridges which are intended for field service, or which are not contained in metal-lined cases. They prevent the cartridge wearing out, preserve it from damp, and prevent dust from working its way into the limber-boxes.

Cartridge-cases.—Leather cartridge-cases are in seven sizes, and are used to bring up the cartridges from the magazine with S.B. ordnance and rifled ordnance under 7-inch except field.

Directions for Making up Cartridges.—When making up cartridges, the floor of the laboratory is covered with leather hides or wadmill tilts, to diminish risk of accidents from grit or sand. The men are required to change their clothing and put on magazine slippers. All loose grains of powder on the floor are to be at once swept up. Detailed directions to be observed when making up cartridges are hung up in laboratories, and must be strictly carried out.

CHAPTER VI.

PROJECTILES.

Projectiles for R.M.L. Ordnance.

General Description.—Projectiles for R.M.L. ordnance are cylindro-ogival in shape; the bodies being cylindrical, the heads ogival. The projectiles for each nature of gun are brought about up to the same weight; they vary in length, therefore. A length of between 2 and 4 calibres is necessary in order to obtain accurate shooting. A long projectile requires a higher velocity of rotation to keep it steady in its flight than a shorter one.

Up to the 40-pr., projectiles for R.M.L. guns have no extractor holes; 64-pr. shells have three, and those for higher natures two.

The various natures of R.M.L. projectiles fired are:—

Armour-piercing projectiles.
Common shell, including double shell.
Shrapnel shell.
Case shot.
Star shell.

Armour-piercing Projectiles.—Those in the Service consist of Palliser shot and shell: but the latter are the only natures now made. They are used with 7-inch guns and upwards, and are made of a special white cast iron.

In order to insure density and soundness in the head, they are cast heads down; and further, the latter are cast in an iron chill or mould, by which means, owing to the conductivity of the metal mould, the molten mass rapidly cools, and gives great hardness and crushing strength but considerable brittleness to the head of a Palliser projectile.

The bodies are cast in a sand mould, that part acquiring by that means more tenacity but less hardness than the head.

The fracture of a Palliser shell shows the metal of the head to be white, whilst that of the body has a mottled appearance, though both came out of the same ladle.

The ogival head is struck with a radius of 1½ diameter, which is increased to two diameters in those now made.

These projectiles were nearly equal to steel shell as regards penetration of wrought iron; but they do not possess sufficient tenacity to enable them to be effectively employed against compound or steel-faced armour.

Armour-piercing projectiles will in future be of steel. Stud holes in these projectiles form lines of weakness, and consequently studded shells are inferior as regards penetration to studless ones.

The shells are tested in manufacture by a water pressure of 100 lbs. on the square inch, and by a hammer test on their bases to detect any weak or porous portion: they are lacquered internally with red lacquer, and the bursting charge of shell L.G. powder is contained in a serge bag to reduce the risk of a premature burst, and completely fills the shell.

The filling hole is in the centre of the base, and is bushed with cast iron; the bush is cast in the shell, and on it is cut the screw-thread into which the gun-metal plug screws, the iron of the shell being too hard to admit of tool work.

To fill the shell, it is placed upon its point inserted in a block of wood hollowed out for the purpose: it is supported by a shell-holder, and filled by means of a funnel and filling rod. The heavier natures are up-ended by a tackle provided for the purpose in the laboratory.

No fuze is required to ignite the bursting charge: the latter is on firing set back into a hard compact mass, which on impact against iron is thrown forward into the narrow conical part of the interior of the shell, and the friction is sufficient to ignite it.

Common Shell.—Common shell are used with all natures of ordnance, being destined for the destruction of material or as a projectile against troops behind cover, and against wooden ships, &c.

They are of cast iron, and cast in a sand mould; the thickness of the walls is from $\frac{1}{5}$th to $\frac{1}{8}$th of the diameter. It is desirable that they should contain as large a bursting charge as possible, and still be strong enough to resist the shock of discharge, and impact against material.

These shells are all lacquered inside, and the bursting charge is contained in a serge bag in the case of 80-pr. shells and upwards; in these natures a primer bag containing 7 oz. of some fine-grained powder is inserted at the top of the bursting charge next to the fuze, in consequence of the flash from the fuze not being always sufficient to penetrate the serge: in the case of shells filled from the base three primers are inserted before the bursting charge is put in.

The percussion fuzes used with common shell above 40-pr. are Pettman's G.S. direct action fuze; the large percussion fuze; and the R.L. fuze up to 40-pr. inclusive.

All common shell down to the 40-pr. inclusive are bushed with gun-metal.

Double Shell.—Double shell are only made for the 7-pr. and 7-inch R.M.L. guns: in construction they resemble common shell

but are longer, that for the 7-inch being 4 calibres: they are inaccurate at long ranges.

Shrapnel Shell.—Shrapnel shell are used with all natures of rifled ordnance. The body consists of a cast-iron shell having walls and base of nearly the same thickness as common shell for the same gun. In the case of 7-inch shrapnel and upwards there are six grooves or lines of least resistance cast in the interior and in the base, in order to facilitate its breaking up uniformly.

At the base the shell contracts so as to form a chamber for the bursting charge, which is contained in a tin cup fitting into the chamber. Above this is a wrought-iron disc fitting over the coned top of the tin cup; a wrought-iron pipe is screwed into a centre hole in the disc, and extends up through the centre of the shell. It is slightly recessed at the top, and into it fits the lower end of a gun-metal socket, the lower portion of which is tapped to receive a screw primer, the upper portion being tapped for the G.S. pitch and taper.

Round the central tube are the bullets, which are iron sand shot about 4 oz. in weight for calibres above 9-inch, 2 oz. for 7-inch, 8-inch, 9-inch, and mixed metal (4 lead, 1 antimony), 14 to the lb., for 80 and 64-prs. Melted rosin is poured in amongst them to keep them from knocking about; and a brown paper lining, to prevent the rosin adhering to the shell, is inserted. A felt ring is placed on the top of the bullets. The head is of Bessemer metal struck with a radius of about one diameter; it is lined with wood, and is lightly attached to the body by rivets and twisting pins, covered with a band of solder.

In the case of shrapnel for 40-prs. and lower natures, the central tube is of gun-metal, in the top of which is screwed in the metal primer. A tin socket fits over the top of the tube, and is soldered to it, and the gun-metal socket fits into the upper portion of the tin socket.

64 and 80-pr. shrapnel have weakening grooves in the base only, lower natures have none. There is a thin wooden tube round the central iron tube of 64 and 80-pr. shrapnel.

The object of the primer in shrapnel shell is to convey the flash from the fuze to the bursting charge at the base, and also to prevent any powder working up into the fuze socket; it is made of gun-metal and filled with loose powder; the top is solid, with a cup-shaped recess containing three small holes; the bottom is closed with a thin brass disc.

The bursting charge of shrapnel is of quick-burning powder,

* Mark III. primer, which is the latest pattern used, has the top made larger in diameter so as to form a shoulder, under which a leather washer soaked in ozokerine is placed.

and in quantity just sufficient to open the shell; time fuzes are generally used, the use of percussion shrapnel being exceptional.

This shell is essentially a man-killing projectile, its effect on material being very small. The greater the velocity of the shell at the time of bursting, and the less its angle of descent, the greater will be its effect; consequently at long ranges, the shell having a low velocity and a high angle of descent, the shell must be burst much closer to the object than at short ranges. The cone of dispersion of the bullets is from 7° to 12°, and shrapnel from medium and heavy guns may be burst 400 or 500 yards short at short ranges, decreasing that distance as the range increases.

The effect of shrapnel depends to a great extent on the results of the fire being correctly estimated; it is often possible to do this, by noting visible marks of grazing of the bullets.

7-pr. Shrapnel.—The shrapnel for the 7-pr. of 400 lbs. has a steel body, the head of malleable cast iron is screwed on, the base of the same metal is riveted on. The bursting charge is contained in the head, the tube down the centre and wooden head being dispensed with: there is thus greater capacity for the bullets.

Case Shot for R.M.L. Guns.—These projectiles must be strong enough not to set up on discharge and take the rifling, and not to be easily injured in travelling, &c.; further, they must be weak enough to release their contents on leaving the gun.

Up to and including 7-inch, with a few exceptions, a case shot has the body made of tinned iron in three pieces, soldered longitudinally together: the bottom of tin is soldered to the body and has an iron ring riveted outside: the top end is fringed and bent down, and soldered on to a tinned iron top.

Above 7-inch the body is made of one piece fringed at both ends, the bottom being an iron disc, top as before. Up to 16-pr. case shot have no handles, up to 8-inch one handle, above 8-inch two handles, which are in loading placed away from the charge.

All case shot contain three loose wrought-iron segments as a lining, 64-pr. and 80-pr. case have six.

Up to 40-pr. they contain mixed metal balls, for higher natures 8-oz. sand shot: the balls are packed in clay and sand.

Up to 7-inch case shot weigh about $\frac{3}{4}$ths of the other projectiles; above 7-inch about the same weight as a spherical projectile of the same diameter.

The more recent patterns are brought about up to the weight of the other projectiles.

Two case shot would as a rule be fired at once except in those of the more recent patterns: they are effective up to 800 or 900 yards from heavy guns and 300 to 400 yards from lighter

natures: their effect is greatly increased if the ground is hard and causes the bullets to ricochet.

Case shot for 12·5-inch, 16-inch, and 17·72-inch guns have a wrought-iron stay bolt passing longitudinally down the centre and secured at either end.

Star Shell.—Star shell is used with the 7-pr., and consists of a thin iron shell having a chamber in the base to take the bursting charge, over this is a wrought-iron disc with a hole in the centre. The interior is filled with 13 stars, consisting of paper cylinders filled with magnesium light composition; they give a brilliant light and burn for about 18 seconds. The top of the shell is of wood covered with tin, and contains a fuze socket. Quick match serves to ignite the stars and to convey the flash of the fuze to the burster. It can be fired also from the 9-pr. gun.

Spherical star shell are used with R.M.L. howitzers (see Table).

Studded Projectiles for R.M.L. Ordnance.

Description.—Projectiles for R.M.L. ordnance, with the exception of case shot, were formerly all provided with studs for the purpose of giving rotation. They were pressed into under-cut holes, which in the Palliser shells were cast in the projectile and in the other natures were cut.

The studs were made usually of an alloy of copper and tin.

No more studded projectiles are made for 9-inch guns and upwards; but for lower natures they are made, and for 9-inch and upwards they still exist, except for polygrooved guns.

The rear studs of 7-inch projectiles and above are 1·42 inch in width, the grooves in these guns being 1·5 inch wide; the width of the front stud being limited by the amount of twist of rifling at the muzzle: with a uniform twist the front studs exactly resemble the rear ones, but with an increasing spiral the front stud must be reduced to remain opposite the groove in all positions, and is therefore limited in its breadth to enable the shell to pass down the bore; since it must not extend beyond d', Fig. 1, Plate IX., to pass out of the bore, nor beyond l to enable it to be rammed home. A small portion only of the work of rotation falls upon the front studs, their chief use being to steady the projectile.

The height of the studs above the shell is greater than the depth of the groove in the gun, the difference termed "clearance" amounts to ·015 inch.

The body of the shell never comes in contact with the bore, and both direction and twist are given by the studs.

There is windage both over the projectile and over the studs, and practically the projectile is not centered.

The edges of the studs are circular, struck with a radius of from ·3 inch to ·25 inch, according to the nature of gun, and the studs are planed to fit the grooves.

There are two rings of studs in each projectile, except 12-inch and 12·5-inch (I.) which have three; the number of studs in each ring corresponding to the grooves in the gun.

64-pr. projectiles have three rings of copper studs, three in each ring; their form is cylindrical with the sides bevelled off to a certain extent. 80-pr. projectiles have copper and zinc studs; the front stud is made smaller than the rear one, although the gun has a uniform twist of rifling, in order to diminish the strain on the shell when forcing the studs into it: the common shell has an interior strengthening belt running round inside under the front stud.

The disadvantages of studs are that they weaken the shell and do not admit of its being properly centered, i. e. its axis coinciding with the axis of the piece; further, the deep grooves which are few in number weaken the gun, and the strain is not evenly distributed over the bore: there is also loss of some of the force of the powder gas owing to windage; the latter defect, however, has been remedied by the use of gas-checks.

Service Gas-check for Studded Projectiles.—The Service gas-check was introduced for use with studded projectiles for certain guns (*vide* Table), owing to the great rush of powder gas over the top of the projectile especially, scoring the bore to such an extent as to render a heavy gun unserviceable after firing a limited number of rounds.

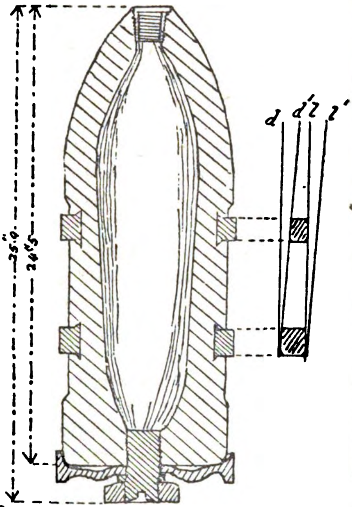
Mark II. Service gas-check is that now in use for studded projectiles of 9-inch and upwards.

It is a disc of copper and zinc, having a hole in the centre; it is painted black on one side; the other side, which is placed against the base of the projectile, being concave and unpainted. It has projections on its edge to fit the grooves of the gun, and is attached to the base of the shell by a plug and nut after the shell is filled: the plug has a shoulder upon it which prevents the nut from binding on the gas-check; the latter can thus revolve freely on the plug for convenience in loading.

By the use of this gas-check not only is the erosion of the bore almost completely checked, but there is an increase in muzzle velocity owing to there being no loss of powder gas; and the projectile is also more nearly centered, hence greater accuracy (Plate IX. Fig. 1). It must be noted, however, that when full charges are used there will be an air space, owing to the projections

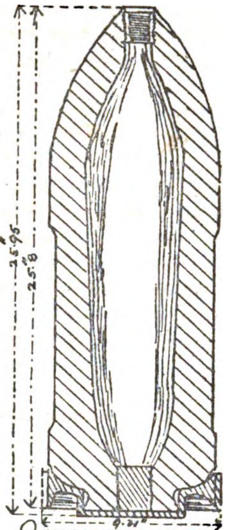
PL IX.

FIG. 1. SCALE $\frac{1}{10.5}$



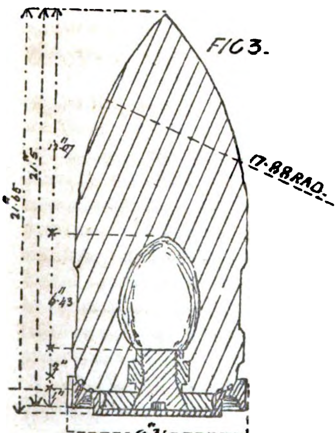
9-INCH COMMON SHELL
& GAS CHECK (II)

FIG 2.



9-INCH STUDLESS C. SHELL
& ROTATING GASCHECK.

FIG 3.



9-INCH PALLISER
STUDLESS SHELL.

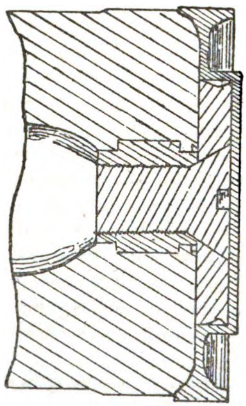


FIG. 4.

BASE OF ALTERED STUDDED SHELL.

[To face p. 48.

on the gas-check bearing against the end of the grooves, and the cartridge not filling up the chamber; hence there will be a loss of muzzle velocity in that case.

Studless Projectiles for R.M.L. Ordnance and Automatic Gas-check.

Description.—Studless projectiles are used with all R.M.L. polygrooved guns, and now also with 9-inch, 10-inch, 11-inch, 12-inch R.M.L. guns rifled on the Woolwich system, the stock of studded projectiles for the latter guns being used up.

The projectiles are cast with a projecting base, with a neck or groove for the attachment of a gas-check which gives rotation. The curved portion of the base of the shell is also cast with radial serrations and one circular groove round it, into which the inner surface of the gas-check is compressed by the pressure on firing, at the same time the gas-check is compressed into the groove or neck round the projecting part of the base, so as to firmly attach it to the shell (Plate IX. Fig. 2).

The gas-check is made with projections round the circumference corresponding with the grooves of the gun; it is inserted loose into the bore, in the proper direction for fitting on the shell; it will then fit itself on the base in ramming home.

The bodies of the shell are unturned, being cast to finished dimensions, leaving 0·2 inch windage; bands are left at the base and head 1·5 inch in width, and are turned or ground down to a windage 0·06 inch.

Studless common shell are filled from the base end, and suitable serge burster bags are issued.

Studless shrapnel shell have their tips painted red.

Altered Studded Projectiles.—The Service common and Palliser studded shell for 9-inch, 10-inch, 11-inch, 12-inch R.M.L. guns are altered as may be required, in order to fit them for use with automatic gas-checks: the base of the projectile is bored and screwed and then fitted with a gun-metal plug having a coned head for fixing a wrought-iron disc one inch in thickness, and of such a diameter and shape as will admit of the use of the same automatic gas-check as is used for the same nature of studless projectile (Plate IX. Fig. 4).

Studless Palliser Shell, Mark II., 9-inch to 12·5-inch.—The latest pattern of studless Palliser shell for R.M.L. guns from 9-inch to 12·5-inch (Mark II.) differ from the ordinary pattern of studless shell in having the base ends fitted with wrought-iron discs (as described in preceding paragraph), for the reception of

Table IV.—Charges and Projectiles

R.M.L. GUNS.	No.	CHARGES. Silk Cloth Cartridges. Battering.	CHARGES. Silk Cloth Cartridges. Full, or Service.	Studded. Common Shell.		Studded. Palliser, or Batt'ring Shell.		Studded. Shrapnel Boxer.	
				Empty, complete with Gas-check.					
		lb.	lb.	lb.	oz.	lb.	oz.	lb.	oz.
17·72-in., 100 tons	I.	450 { Prism.^{1} or Prism.^{2} } In 4 cartridges.	337½ Prism.^{1} or Prism.^{2} In 3 cartridges. { Cartridges for 80 and 100-ton guns are interchangeable.	..		..		..	
16-in. 80 „	I.	450		1640	0	1684	0	1696	0
12·5-in. 38 „	I.	160 P^{2} * 130 P^{2} *f*	100 P^{2} *f*	797	11	805	7	820	9
12·5-in. 38 „	II.	210 Prism.^{2} .. (In 4 cartridges.)	157½ Prism.^{2} In 3 cartridges.	797	11	805	7	820	9
12-in. 35 „	I.	110 P. 140 P^{2} *f* †	85 P. or 67 RLG..	589	4	702	6	*s*610	6
„ 25 „	II.	85 P. or 67 RLG	55 P. or 50 RLG..	473	7	600	4	*s*494	13
11-in. 25 „	II.	85 „ 70 „	60 P. and 53 P. *f*	518	14	542	3	*s*531	15
10-in. 18 „	II.	70 „ 60 „	44 „ 40 „	389	4	405	1½	*s*403	0
9-in. 12 „	V.	50 „ 43 „	33 P., or 30 LG, or RLG	248	11	251	7	*s*254	0
				Empty, without Gas-checks.					
8-in. 9 „	III.	35 „ 30 „	21 P., or 20 LG, or RLG	166	0	174	12	179	0
7-in. 7 „	IV.	30 „ 22 „	17 P., or 14 LG, or RLG	106	14	112	1	115	10
„ 6½ „	III.	30 „ 22 „	„ „ „ „	106	14	112	1	115	10
7-in. 90 cwt.	I.	22 P.	14 RLG or 17 P...	106	14	112	1	115	10
6·6-in. 70 „	I.	25 P.	.. ..	..		..		..	
80-pr (convd.) 5 tns	I.	.. ..	12 P., or 10 LG, or RLG	71	1	..		78	10
64-pr. *b* 64 cwt.	I & II.	.. ..	8 „ „ or RLG^{2}	57	6	..		66	0
„ *b* „	III.	{12 RLG, or 11 RLG^{2}}	10 & 8 LG or RLG	57	6	*p* 88	2	66	0
„ *b* (convd.) 71 cwt	I.	.. ..	8 LG or RLG, or RLG^{2}	57	6	..		66	0
„ *b* „ 58 „	I.	.. ..	8 „ „ „	57	6	..		66	0
40-pr. 34 „	I.	.. ..	7 RLG or RLG^{2}	*u* 37	7½	..		*u* 42	11½
„ 35 „	II.	.. ..	7 „ „	*u* 37	7½	..		*u* 42	11½
25-pr. 18 „	I.	.. ..	4 „ „	23	3½	..		25	0
16-pr. 12 „	I.	.. ..	3 „ „	14	15½	..		17	13
13-pr. 8 „	I.	.. ..	3½ RLG^{2}	..		..		..	
9-pr. 8 „	I. & II.	.. ..	1¾ LG, RLG, or RLG^{2}	8	9½	..		9	12
„ 6 „	I.	.. ..	1½ LG, or RLG^{2}	8	9½	..		9	12
„ 6 „	II. & III.	.. ..	1¾ RLG „	8	9½	..		9	12
7-pr. „ 400 lb. In two parts.	} I.	.. ..	1¼ RLG^{2}	..		..		..	
7-pr. 200 „	II.	.. ..	¼ FG or RFG	6	14	..		7	10½
„ 150 „	III.	.. ..	0 6 ounces	6	14	..		7	10½
„ 200 „	IV.	.. ..	0 12 „ „	6	14	..		7	10½
HOWITZERS.									
8-in., 70 cwt. ..	I.	.. ..	11½, 7, and 3½-lb. RLG^{2}	..		..		..	
„ 46 „ ..	I.	.. ..	10, 5, and 2½-lb. RLG or RLG^{2}.	171	1	..		..	
6·6-in. 36 „ ..	I.	.. ..	5, 3, 1-lb. RLG^{2}	..		..		..	
6·3-in. 18 „ ..	I.	.. ..	4, 3, 2, and 1-lb. RLG or RLG^{2}	..		..		..	

* In 2 cartridges of 80 lbs.
† In 2 cartridges of 70 lbs.
b Take 32-pr. S.B. ammunition if required.
f For sea service only.
p The battering shell is the only projectile that takes a gas-check.

FOR R.M.L. ORDNANCE.

PROJECTILES.

Projectiles. Bursting Charges. Common. Shell, L.G.	Palliser. Shell, L.G.	Shrapnel. R.F.G., F.G., or pistol.	Studless Projectiles. Common Shell. (Empty, complete with Gas-check.)	Palliser or Battering Shell. (Empty, complete with Gas-check.)	Shrapnel Shell. (Empty, complete with Gas-check.)	Bursting Charges. Common. Shell, L.G.	Battering. Shell, L.G.	Shrapnel. R.F.G., F.G., or pistol.
lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
..	..	..	1922 0	1968 0	1995 0	78 0	32 0	5 0
60 0	16 0	4 3	1640 0	1684 0	1696 0	60 0	16 0	4 3
29 4	11 14	2 7	785 0	809 6	815 9	33 0	8 10	2 7
29 4	11 14	2 7	785 0	809 6	815 9	33 0	8 10	2 7
41 0	10 4	1 15	686 12	706 12	..	27 4	7 4	..
38 10	15 8	1 15	590 10	608 6	..	23 6	5 10	..
30 2	6 12	1 12	526 0	543 2	545 15½	22 0	4 14	2 0½
21 0	7 4	1 9	390 7	406 0	408 6	19 9	4 0	1 10
13 12	6 0	1 5	241 8	253 5	254 11	14 8	2 11	1 5
15 2	4 8	1 0	..	..	..	..	..	..
9 4	2 10	0 12	..	..	..	..	..	..
9 4	2 10	0 12	..	..	..	..	..	..
9 4	2 10	0 12	..	..	..	..	..	..
..	..	..	*t* 94 2½	*t* 97 12½	..	5 9	2 1	..
8 10	..	0 9	..	..	..	..	..	..
7 2	..	0 9	..	..	..	..	..	..
7 2	2 0*p*	0 9	..	..	..	..	..	..
7 2	..	0 9	..	..	..	..	..	..
7 2	..	0 9	..	..	..	..	..	..
2 8	..	0 4½	..	..	..	..	..	..
2 8	..	0 4½	..	..	..	..	..	..
1 12	..	0 3	..	..	..	..	..	..
1 2	..	0 1½	..	..	..	..	..	..
..	..	..	12 6	..	12 15½	0 10	..	0 0¾
0 7½	..	0 0¾	..	..	..	..	..	..
0 7½	..	0 0¾	..	..	..	..	..	..
0 7½	..	0 0¾	..	..	..	..	..	..
..	..	..	6 12	..	6 15½	0 4	..	0 0½
0 6½	..	0 0½	..	..	..	..	..	..
0 6½	..	0 0½	..	..	..	..	..	..
0 6½	..	0 0½	..	..	..	..	..	..
..	..	..	*w* 166 9	*w* 175 13	..	13 10	4 0	..
15 2	..	..	..	..	..	..	..	..
..	..	..	*t* 94 2½	*t* 97 12½	..	5 9	2 1	..
..	..	..	*w* 62 6	..	..	7 2	..	..

s Do not have gas-checks.
t Common and battering shell 6·6-inch gun and howitzer are interchangeable.
u Fitted with gas-checks.
w Star shells are fired from all howitzers except 6·6-inch. 8-inch, weight 21 lbs. 9 oz., charge 2½ lbs.; 6·3-inch, weight 11 lbs. 5 oz., charge 2 lbs., 15 seconds fuze.

the cupped part of the gas-check, instead of the projecting part of the base forming part of the cast iron of the shell itself.

This alteration in pattern was made in consequence of it having been found that the cast iron of the base end was liable to be injured in transit, &c. (Plate IX. Fig. 3).

Rope grummets are issued with studless shell placed over the projecting part of the base for its protection, which must be removed before loading.

Projectiles for 16-*inch and* 12·5-*inch* (*II.*).—The studless shell for the 16-inch 80-ton and 12·5-inch 38-ton guns have in the side of each an oblong hole 1·15 inch in width, 0·6 inch deep, and 2·5 inches long; the centre of the hole being 4·5 inches in rear of the centre of gravity: this hole is for the reception of the pawl on the trolley used for bringing the shell up to the gun. On the opposite side of the shell there is a hole for the reception of an eyebolt to which is attached the tackle for lifting the projectile up to the trolley.

The 80-ton shrapnel shell contains 860 4-oz. sand shot, or 1141 3¼-oz. sand shot, the 38-ton shrapnel 296 or 364 respectively.

Projectiles for Old Pattern Armstrong R.B.L. Guns.

Natures.—The projectiles used with these guns are segment shell, common shell, shrapnel shell, and case shot. Solid shot have been made which are used for practice only.

Segment Shell.—Segment shell is a projectile peculiar to this class of guns. It consists of a thin cast-iron cylindro-conoidal body, lined with cast-iron segments, built up in layers, having a cylindrical chamber in the centre: the base is closed with a disc of cast iron.

The shell is strong against external pressure, but a small bursting charge will open it.

A coat of an alloy of 19 parts of lead to 1 part of antimony extends from base to shoulder; the alloy also flows in between the segments and lines the powder chamber, and there is a recess in the base of the iron disc over which the alloy flows, and the disc is thus kept in its place. A cannelure runs round the shell to take any lead stripping off the front part.

The shell is first dipped in a zinc bath, which causes the lead coating to become chemically attached to the iron.

Segment shell are very effective against troops in column, and should be burst close up to them; the shape of the segments is unfavourable to prolonged flight after the shell is opened. They have also given good results against troops behind a thin wall,

TABLE V.—CHARGES AND PROJECTILES FOR R.B.L. ORDNANCE (OLD PATTERN).

ORDNANCE.	CHARGES.	PROJECTILES.					
		Empty.			Bursting Charges.		
Old Pattern Armstrong Guns.	Full or Service. * Serge Cartridges.	Common Shell. (With Lead Coating.)	Segment Shell. (With Lead Coating.)	Shrapnel Shell. (With Lead Coating.)	Common Shell.	Segment Shell.	Shrapnel Shell.
	lb.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz. gr.	lb. oz.
7-in. 82 cwt.	14 P. or 11 LG or RLG	{83 0 98 0}	98 9½	97 0	{6 8 7 10}	3 2 0	0 8
„ 72 „	10 LG or RLG	98 0	98 9½	97 0	7 10	3 2 0	0 8
40-pr. 35 and 32 cwt. ..	5 LG, RLG, or RLG²	37 14	38 9½	39 0	2 4	0 13 0	0 3
20 „ 16, 15, and 13 cwt...	2½ „ „ „	20 8	19 10	..	1 2	700 grs. } Shell, F.G.	..
12-pr. 8 cwt.	1½ „ „ „	10 12	10 8⅓	10 11	0 8	550 „ } Shell, F.G.	0 0¾
9 „ 6 „	1 2 ounces „	8 2½	8 3⅓	8 11	0 6	300 „ } Shell, F.G.	0 0¾
6 „ 3 „	0 12 „ „	..	5 7	..	..	200 „ } Shell, F.G.	..

* Except 40-pr., which has silk cloth.

and they would be effective against wooden ships. A percussion fuze would be usually employed with them.

Common and Shrapnel Shell.—The common and shrapnel shell are similar in construction to those described for R.M.L. guns, with the exception of the lead coating.

The bursting charge of the common shell of the 40-pr. R.B.L. gun is now contained in a serge bag, having the neck and upper part of shalloon, in consequence of premature bursts having occurred: with the bag, the average bursting charge is 2 lbs. 3 oz.

Shrapnel shell, though existing for 40-pr. and 7-inch R.B.L. guns, do not form part of their equipment.

Case Shot.—Case shot for these guns have solder studs to prevent their being rammed home too far into the bore, the studs being at the rear end; in other respects they are similar to ordinary case shot; the case for 7-inch R.B.L. is suitable for the 7-inch R.M.L. gun.

Projectiles for Smooth-bore Ordnance.

Natures.—These consist of—(I.) Shot, viz. solid, case, grape, and sand. (II.) Shell, viz. common, naval, mortar, hand grenade, diaphragm shrapnel.

Shot.—*Solid shot* are made for all calibres of guns except 8-inch and 10-inch shell guns, and are of cast iron.

Case are made for all S.B. ordnance, except mortars.

Grape shot consist of sand shot held in position by four circular iron plates, pierced with holes to grip the shot; an iron spindle passes through the plates, and a nut at the head of the spindle binds all together: they are still in the Service, though superseded by case.

Sand shot are cast-iron balls varying in weight from 4 lbs. to 1½ oz., and are chiefly used in the manufacture of shrapnel and case for heavy ordnance.

Shell.—Common shell are used with all S.B. ordnance: they have the common fuze-hole gauge, and are fitted with wooden bottoms attached by a gun-metal rivet: the fuze hole is tapped throughout to take Pettman's L.S. fuze, and marked with a +

Naval shell have the general Service gauge, and the wood bottoms are fixed by two rivets.

Mortar shell have the mortar gauge which is larger than the common: they have no wood bottoms, and are used with 8-inch, 10-inch, and 13-inch mortars.

Hand-grenade shell are of two sizes, 3 and 6-pr., being used with a special fuze: they can be thrown by hand, and are used in the defence of places against assault.

Diaphragm shrapnel have the common gauge, and are fired

from all S.B. ordnance except mortars. The shell is made of thin cast iron, weakened by four grooves down the side. A wrought-iron cup or diaphragm divides the shell into two unequal parts; the smaller and upper portion containing the bursting charge, the larger one the bullets, which are of lead and antimony.

Carcasses are incendiary shells, and are fired from all S.B. ordnance: before firing, the plugs and plaster over the three vents must be removed; they will burn from 3 to 12 minutes, and cannot be extinguished by water.

Ground light balls are fired from mortars for the purpose of lighting up an enemy's works: they consist of a skeleton iron frame covered with canvas and filled with composition; the vents must be uncovered before firing.

Parachute light balls are fired from mortars for lighting up an enemy's works; they float in the air whilst burning from 1 to 3 minutes, but are easily affected by the wind.

Weights of Mortar Shell.—The 13-inch mortar of 36 and 100 cwt. fires a shell weighing 195 lbs. with a bursting charge of 10 lbs. 15 oz.

The 10-inch mortar of 18 cwt., a shell 87 lbs. with a bursting charge of 5 lbs. 4 oz.

The 8-inch mortar of 9 cwt., a shell of 46 lbs. with a bursting charge of 2 lbs. 9 oz.

TABLE VI.—CHARGES OF S.B. ORDNANCE.

S.B. Guns.		Charge.		S.B. Guns.		Charge.	
		lb.	oz.			lb.	oz.
18-pr.	42 cwt.	6	0	68-pr.	95 cwt.	16	0
24 „	50 „	8	0	68 „	112 „	18	0
32 „	50 „	8	0	Mortars.			
32 „	58 „	10	0	13-in.	100 cwt.	20	0
42 „	84 „	14	0	13 „	36 „	9	0
8-in.	65 „	10	0	10 „	18 „	4	0
10 „	86 „	12	0	8 „	9 „	2	0

PROJECTILES FOR NEW PATTERN B.L. GUNS.

4-inch of 13 *and* 22-*cwt. Guns.*—The rotation was effected in the earlier patterns by means of a copper driving ring with three cannelures attached to the base end by six copper rivets and by a ring of solder at the part which extends round the base. In the latest patterns the shell has at a distance of 1·25 inch from the base end a groove 0·5 inch wide, into which a continuous copper ring is pressed.

The length of the common shell is 12·05 inches, and that of the shrapnel 11 inches; the latter contains 40 bullets at 34 per lb. and 105 at 20 per lb., and is of the ordinary pattern. The case shot has a copper ring and six studs fixed round the body to act as stops. The weight of each projectile is 25 lbs.

5-inch of 36-*cwt Guns.*—The projectiles are common and shrapnel shell and case shot. The common shell is cast to finished dimensions; it is 16 inches long, and its rotation is effected by means of a continuous copper ring pressed into a groove at a distance of 0·95 inch from the base. The ring is 0·7 inch in width; the diameter over the body of the shell is 4·96 inches, and over the ring 5·12 inches; the weight filled is 50 lbs. The case shot is of tin, filled with 450 mixed metal balls, and weighs 50 lbs.

6-inch of 80 *cwt.*—The projectiles for this gun are common shell, double shell, Palliser shell, shrapnel shell, and case shot. Rotation is effected by a driving ring of copper, with cannelures attached to the base end. Weight 80 lbs.

The shrapnel shell differs from ordinary patterns in having the bursting charge contained in the head. The whole of the body is filled with bullets, and a ring of cast-iron segments is placed at the base end. The body of the shell is of steel, the head and base of wrought iron; the latter is connected to the body by rivets, the head being screwed to the upper end; the whole being secured at the top by a wrought-iron plate, on which is fitted an arrangement for carrying an additional number of bullets (Plate X. Fig. 1). The case shot has the sides and ends of steel; the sides are in two segments, held together by two brass clips in the centre. The ends are held together by two longitudinal pieces up the interior of the shell; two brass studs are placed near the rear end of the case, to serve as stops in place of the rings on the shell. The weight is 70 lbs., and length 14 inches.

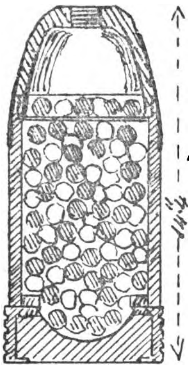
The length of the common shell is 17·9 inches, double shell 20·4 inches, and of the Palliser shell 15·4 inches.

6-inch of 81 *cwt.*—Rotation is effected by a driving ring of copper 0·74 inch wide, fitted, at a distance of 1 inch from the base end, into a groove stepped and undercut to receive it. In the latest patterns the bottom of the groove is made with four > shaped ribs round it, instead of being stepped (Plate X. Fig. 4). The common and Palliser shell used with this gun are filled from the base end: the shrapnel shell is of the ordinary pattern. A light common shell 17·8 inches long is used in addition, having a white ring painted round the head to distinguish it from the common shell, which is 21·55 inches in length; it is filled from the base. The case shot is of sheet iron, and has three studs of

SCALE $\frac{1}{8}$

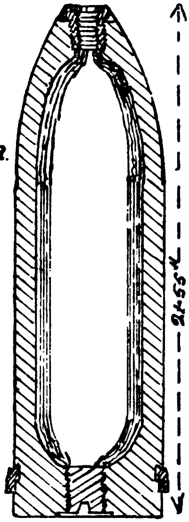
PL X.

FIG. 1.



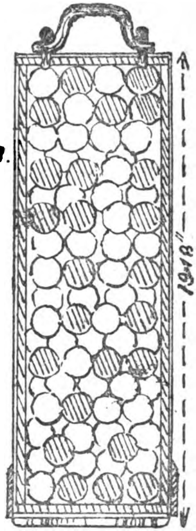
6-INCH 80 CWT (80 Pr) B.L.
SHRAPNEL SHELL.

FIG. 2.



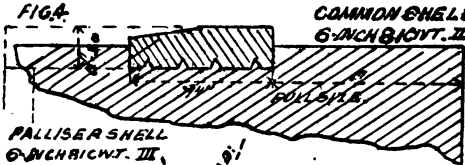
COMMON SHELL.
6-INCH 81 CWT. II

FIG. 3.



CASE SHOT 6-INCH
81 CWT. B.L. GUN. I

FIG. 4.



PALLISER SHELL
6-INCH 81 CWT. III.

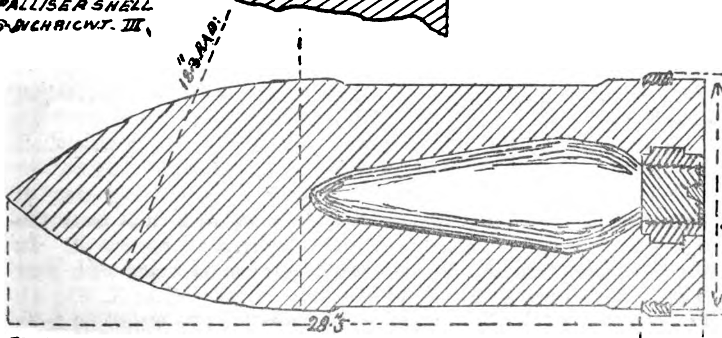


FIG 5

PALLISER SHELL 8·2-INCH B.L. GUN.

SCALE $\frac{1}{8}$

[To face p. 56.

TABLE VII.—CHARGES AND PROJECTILES FOR NEW PATTERN B.L. GUNS.

Ordnance.	Charges.		Projectiles.			Bursting Charges.			Approximate Total Weight of Projectiles.
	Battering.	Full.	Palliser.	Common.	Shrapnel.	Palliser Shell.	Common Shell.	Shrapnel Shell.	
	lbs.	lbs.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lbs.
4-inch 13 cwt. ..	..	$3\frac{1}{4}$ RLG[2]	..	23 10	23 14	..	1 6	0 3	25
4 ,, 22 ,, ...	..	13 P.	..	23 10	23 14	..	1 6	0 3	25
5 ,, 36 ,, ...	..	16 P.	..	46 $4\frac{3}{4}$	..	..	3 5	..	50
6 ,, 80 ,, ...	34 P.	25 P.	78 7	75 0	79 1	1 9	5 0	0 5	80
6 ,, 81 ,, ...	34 P[2].	19 P[2].	98 13	{ 93 10 63 10 }	99 9	{ 6 6 6 6 }	..	0 7	100
6 ,, 89 ,, ...	42 P[2].	..	100 0	..	..	..	..	..	100
8 ,, 13 tons ..	100 Prism[1].	..	210 0	198 8	209 $0\frac{1}{2}$	..	11 8	0 $15\frac{1}{2}$	210
9·2 inch 18 ,, ..	200 C[2].	..	376 4	364 8	378 10	3 12	15 8	1 6	380
10 ,, 26 ,, ..*	300 C[2].	..	*500 0	..	..	..	..	..	500
12 ,, 43 ,, ..	260 Prism[1].	..	714 0	682 4	584 7	6 4	24 12	1 14	714
12 ,, 46 ,, ..	450 C[2].	..	850 0	..	..	..	..	..	850
13·5 ,, 63 ,, ..*	650 C[2].	..	*1250 0	..	..	..	..	..	1250
16·25 ,, 110 ,, ..*	900 C[2].	..	*{ 1800 or 2000 }	..	..	..	..	..	{ 1800 or 2000
Field Guns.									
12 pr. $7\frac{1}{2}$ cwt.	..	4 P.	..	$12\frac{1}{2}$ 0	..	..	..	..	$12\frac{1}{2}$
22 ,, 12 ,, ...	..	7·5 P.	..	22 0	..	..	..	..	22

* Probably.

mixed metal fixed round the base end, to act as stops when loading.

The weight of each nature is about 100 lbs. (Fig. 3).

9·2-inch of 18 tons.—The bodies of the shells are cast to finished dimensions, leaving 0·2 inch windage: bands are left at head and base, having a windage of 0·05 inch. Rotation is effected by a continuous copper ring. A small hole is made in the side of each shell in line with its centre of gravity, for the reception of an eye-bolt for the lifting tackle.

The common shell is 32·9 inches long, the Palliser is 28·5 inches, its head being struck with a radius of about 2 diameters; the shrapnel is 31·5 inches long, and contains 420 2-oz. sand shot.

The total weight of each projectile is 380 lbs. (Fig. 5).

12-inch B.L. Gun.—The projectiles for this gun are similarly constructed to the above, having a similar rotating ring: the lengths are—common shell 36·1 inches, Palliser 32·3 inches, shrapnel 34·75 inches; the latter containing 340 4-oz. sand shot.

The total weight of each projectile is 714 lbs.

Common and double shells below 6-inch have no bags: for 6-inch and upwards the bursting charge is enclosed in serge bags, the end next the fuze hole being of shalloon. A primer of 7 oz. F.G. powder in a shalloon bag is placed next the fuze hole, and in the case of shells filled from the base end three primers are inserted before the bursting charge is put in.

Shells filled from the base are supplied with a disc of lead, with a projection fitting into the keyhole of the plug; the whole disc is then hammered tightly down over the base plug.

The shrapnel shell of the 6-inch 80 cwt., having the bursting charge in the head, requires no primer. Other natures of shrapnel shell are filled in the ordinary manner.

CHAPTER VII.

FUZES, TUBES, ETC.

Fuzes for Rifled Ordnance.

Wood Time Fuzes.

Description.—Time fuzes are made of beech wood; conical in shape, to insure their always fitting into the fuze socket, which in all rifled shell is of the G.S. gauge and taper.

The following are the time fuzes in the Service at the present time:—

TABLE VIII.—TIME FUZES.

Name of Fuze.		Time of Burning at Rest.	No. of Powder Channels.	Graduated to	Charged with	
	secs.	secs.		secs.		
Time wood M.L.	5	5	2	¼	Mealed powder (1″ in 2½ secs.).	Without Detonators.
„ „	9	10	2	½	Fuze composition (1″ in 5 secs.).	
„ „	15	15	6	¼	Fuze composition (1″ in 7½ secs.).	
„ „	20	20	Nil	Seconds	Fuze composition (1″ in 5 secs.).	
„ „	30	30	8	¼	Fuze composition (1″ in 10 secs.).	
„ B.L.	5	5	2	¼	Mealed powder (1″ in 2½ secs.).	With Detonators.
„ „	9	10	2	½	Fuze composition (1″ in 5 secs.).	
„ with detonator	15	15	6	¼	Fuze composition (1″ in 7½ secs.).	

Of these the 5, 9, and 20 seconds, either with or without detonators, are obsolete as regards manufacture, but a stock still exists which is to be used up.

The 15 seconds replaced the 5 and 9 seconds, and the 30 seconds the 20 seconds fuze.

The fuze composition of time fuzes consists of pit mealed powder, saltpetre and sulphur, the rate of burning being regulated by the amount of pressure the pellets of the composition undergo, and also by the proportions of the ingredients. An addition of pit mealed powder accelerates the rate of burning, an addition of saltpetre and sulphur retards it.

M.L. WOOD TIME FUZES.

15 *seconds M.L. time fuze* is charged with 2 inches of fuze composition burning at the rate of 1 inch in 7½ seconds: it has 6 powder channels filled with pistol powder, and side holes into which pistol powder is pressed. The fuze is graduated to ¼ seconds, the side holes being numbered 1, 1·5, 2, 2·5 . . . . 30; the figures of the side holes are placed so as to read when the head of the fuze is

towards the body; the side holes are stamped and coloured yellow, and are on the left of their corresponding numbers.

The head is closed by a gun-metal plug screwed in; round the head of the fuze is a groove, into which quick-match priming is wrapped, which also passes through two holes into the fuze, and is looped round the pin of the gun-metal plug. The priming in the groove is protected by a copper band enclosed in tape and covered with paper; this band is removed before the shell is rammed home. There is a paper lining between the wood and the composition to prevent the formation of a space in the event of the wood shrinking, which would cause the fuze to act prematurely. The powder channels are connected at the bottom by quick match, and the last side hole is bored through into the composition (Plate XI. Fig. 2).

In Mark I. fuze the figures of the side holes are reversed, and are placed over the spot into which the bit is inserted, in place of to one side.

The fuze is painted black and drab.

It is used with all R.M.L. guns, except 13-pr., 40-pr., 6·6 inch, and 9 inch.

9 *seconds M.L. time fuze* is similar in general construction: it has only two powder channels and 2 inches of fuze composition, burning at the rate of 1 inch in 5 seconds: it is graduated to half seconds, the side holes being numbered 1, 2 . . . . 20. It is painted black and drab.

5 *seconds M.L. time fuze* is charged with 2 inches of mealed powder, burning at the rate of 1 inch in 2½ seconds: it has two powder channels and side holes graduated from 1, 1·5, 2 . . . . 10, thus reading to quarter seconds. It is painted red and drab.

30 *seconds M.L. time fuze* is charged with 3 inches of fuze composition, burning at the rate of 1 inch in 10 seconds: it has eight powder channels in order to obtain space for side holes graduated to quarter seconds.

The side holes are numbered consecutively in a spiral direction, as in the 15 seconds fuze, but commencing at 30, 30·5 . . . . 60. The fuze cannot therefore be used for times of flight less than 15 seconds. In order to give room for the increased number of powder channels, the lower part of the fuze from the commencement of the side holes is made cylindrical. The gimlet borer must be used with this fuze. It is painted black and drab.

20 *seconds M.L. fuze* is charged with 4 inches of fuze composition, burning at the rate of 1 inch in 5 seconds. It has no powder channels, and is graduated to seconds from 20, 22 . . . . 40. It can therefore only be used with common shell whose times of flight exceed 10 seconds.

Action of M.L. Time Fuzes.—In all the time fuzes without detonators, the quick-match priming is lit by the flash and ignites the fuze composition, which burns down to the hole at which it is bored, when the powder channels flash off into the shell. If the fuze is improperly bored, it will still act at the last side hole, which is bored through into the composition. In the case of the 20 seconds fuze the flame from the composition acts at once through the side hole; this fuze would therefore fail to burst a shrapnel shell where a downward flash is required.

Wood Time Fuzes with Detonators.

15 *seconds wood time fuze with detonator* is similar to the 15 seconds M.L. fuze, with the exception that, in place of the gun-metal plug, there is a detonator secured into the head of the fuze, which is strengthened by a woolding of copper wire round it.

The detonator is a cylinder of gun-metal, and contains a hammer supported by a copper suspending wire 0·03 inch in diameter; below the hammer is a hollow containing a detonating composition of chlorate of potash, fulminate of mercury, and sulphide of antimony. A safety pin of copper wire in Mark III. fuze passes through the hammer and head of the fuze in a direction at right angles to the suspending wire. The pin passing through the hammer obviates any risk of the suspending wire, however thin, being sheared before the safety pin is removed. The latter is withdrawn by the braid at the moment of loading.

Ignition is produced by the shock of discharge setting the hammer back, and thus shearing the suspending wire, and falling on the detonating composition.

There are three holes to allow of the escape of gas at the head of the fuze, which are protected by thin copper discs and papier-mâché wads; the latter are blown out when the fuze is lit, quick-match priming leads up to the holes (Plate XI. Fig. 1). This fuze is used with the 13-pr., 40-pr., 6·6-inch and 9-inch R.M.L. guns, and with the 40-pr. and 7-inch R.B.L. guns.

The 5 *and* 9 *seconds B.L. wood time fuzes* are similar, with the exception of the detonator, to the 5 and 9 seconds M.L. fuzes.

Remarks on Wood Time Fuzes.—A hook borer is used for boring wood time fuzes at the required length: the bit is screwed into the side hole and through the wood into the composition channel: the fuze is held in the borer in the palm of the left hand, its head being towards the body; in this position the bit bores directly into the composition. All time-fuzes are marked in red numerals with the month and year of manufacture, the mark or pattern, and the number of thousands of manufacture: this in-

formation being recorded in the practice report in the event of a blind shell or premature burst occurring.

Wood time fuzes will burn nearly 3 per cent. longer for every 1000 feet of altitude; thus at 10,000 feet above sea-level the 15 seconds fuze would burn nearly 20 seconds.

PERCUSSION FUZES FOR RIFLED ORDNANCE.

Description.—Percussion fuzes are of gun-metal, and are constructed to act either on graze and impact, or on impact only. The former kind are required on land, but in the case of a shell fired over water it is preferable that it should burst on impact only, and not on grazing the water.

All except the B.L. plain percussion fuze are tapped with a screw thread to fit the conical general Service fuze hole of the shells. In the absence of a range finder, a shell fired with a percussion fuze is the best means of obtaining the range.

*Natures.**—The percussion fuzes for R.O. in the Service are

Pettman's general Service.
Royal Laboratory, Mark II.
B.L. plain.
Direct action.
Delay action.
Time and concussion (Armstrong's).

Pettman's G.S. Fuze.—This fuze acts on impact only. It is conical in shape, and its body is tapped throughout with a screw thread; it has no safety pin, and requires no preparation before being screwed into the shell.

The names of its parts are: body (*a*), top plug (*b*), plain ball (*c*), steady plug (*d*), detonating ball (*e*), cone plug (*f*), lead cup (*g*), suspending wire (*h*). (Plate XI. Fig. 3.)

Two copper hemispheres are placed over the detonating ball, which is smeared with detonating composition; their object being to render the fuze less sensitive: the whole is covered with silk and gut.

The action of the fuze is as follows: on the shock of discharge the steady plug, detonating ball, and cone plug set back, the suspending wire is sheared, the lead cup prevents rebound, and the stem of the cone plug protrudes through the base.

The detonating ball being released, is on impact dashed violently against the chamber in the body of the fuze and explodes, the flash passing down the cone plug into the shell.

Should the detonating ball not be released from its pivots

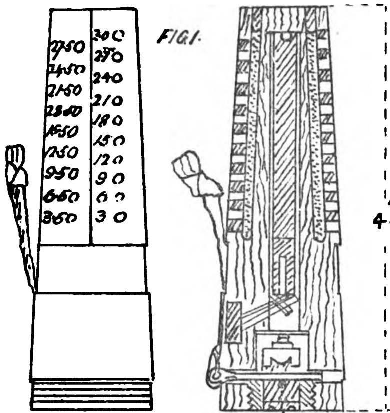
* A large and small percussion fuze will be shortly introduced into the Service.

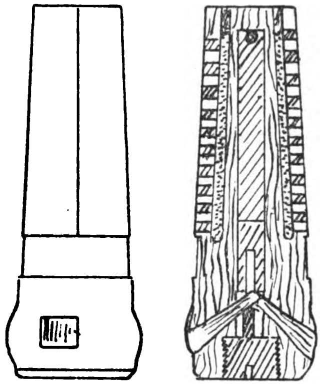
SCALE $\frac{1}{2}$

PL. XI.

FIG. 1.

FIG. 2.

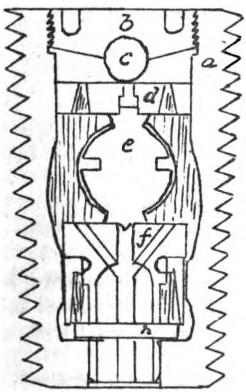




15-SECONDS FUZE WITH DETONATOR.

15-SECONDS M.L. FUZE.

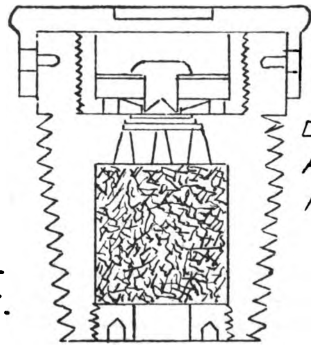
FIG. 3.



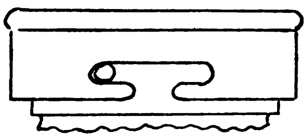
FULL SIZE.

FIG. 4.

DIRECT ACTION FUZE.



PETTMAN G.S. FUZE.



CAP OF DIR: ACT: FUZE.

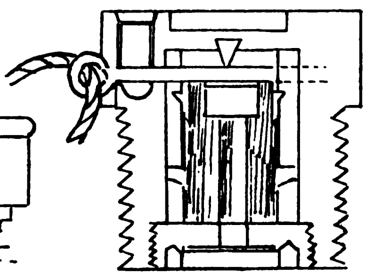


FIG. V.

R.L. FUZE II.

[To face p. 62.

owing to the steadiness in flight of the shell, then the plain ball coming in contact with the ring of detonating composition on the top of the steady plug will act.

This fuze is used with 12-inch R.M.L. guns and upwards when firing battering charges only, as it is not set in action by the full charges of these guns.

R.L. Fuze (Mark II.).—Acts on graze or impact, and consists of a body and bottom plug: in the centre of the top is a steel needle pointing downwards; below this are a guard and pellet with two projections or feathers; in the top of the pellet, which is made of lead and tin, there is a cap containing detonating composition.

The safety pin passes through the head and through the guard which it supports; it is withdrawn at the moment of loading; a small lead pellet closes up the hole and prevents the flash on discharge passing into the fuze and so causing a premature.

The fuze is screwed into the shell with the general Service key, and on the shock of discharge, the guard sets back, shearing off the two feathers of the pellet, and locks itself on to the pellet by the projection on the latter wedging into the undercut recess in the guard. On graze or impact the pellet and guard fly forward and drive the cap against the steel needle which pierces the thin brass disc and ignites the detonating composition; the flash passes through the hollow in the pellet into the shell, blowing out the brass disc which closes the fire-hole in the bottom plug (Plate XI. Fig. 5). Mark I. fuze can only be used with 7 and 9-pr. guns; it was found to fail with heavier charges.

Mark II. is used with smaller natures of breech-loading guns, and with 40-pr. R.M.L. guns and under.

B.L. Plain Percussion Fuze.—This fuze acts on graze or impact; it is used with common and segment shell of the old pattern R.B.L. guns up to 20-pr.; it has no screw thread on the exterior of the body, but is dropped into the shell and the plug replaced. In construction, &c., it is almost similar to the R.L. fuze.

Direct-action Percussion Fuze.—This fuze is not affected in any way by the shock of discharge, whether heavy or small charges are used. It will act on direct impact or on graze if the angle of elevation is about 10 degrees or over.

The body is tapped on the exterior to the general Service taper and pitch; the lower part is hollowed out to receive a blowing charge of fine powder; the bottom is closed by a bottom plug.

A screw plug is screwed into the upper portion of the body, and contains the needle disc of copper, in the centre of which is a steel needle, and below it is the cap of detonating composition.

A cap fits over the top of the fuze, and on each side of it is a slot to fit over the brass pins in the body, by which means it is

secured to the fuze. A square hole for the G.S. key is cast in the upper surface for the purpose of screwing the fuze into the shell.

The fuze is prepared by removing the cap, and on impact or graze, at such an angle that the nose of the shell enters the ground, the needle is crushed down on to the detonating composition which ignites the mealed powder in the conical holes and the fine-grain powder and fires the charge. The cap should not be removed until the moment of loading.

The fuze is used with R.M.L. guns from 40-pr. to the 12-inch of 25 tons, with the 7-inch R.B.L., and with 6-inch B.L. guns and upwards (Plate XI. Fig. 4).

The Delay-action Percussion Fuze was introduced for use with the battering shell of the 64-pr. gun. It consists of a body; percussion arrangement of pellet with detonator, guard, suspending wire, and steel pin or needle; air space and delay arrangement of fuze composition.

On being fired, the suspending wire is sheared and the guard set down upon the pellet, and the detonator is fired upon impact; the flash from the detonator then passes through the air space and ignites the fuze composition, which burns for five or six seconds, and thus allows the shell to bury itself in the object which it strikes before exploding.

The fuze is screwed into the base of the shell and has the word "fuze" stamped upon it to distinguish it from the ordinary gas-check plug.

Armstrong's Time and Concussion Fuze.—The body of this fuze is made of lead and tin, with a small mixture of antimony; the other parts are of gun-metal (Plate XII. Fig. 1).

The fuze consists externally of two parts, viz. the fuze proper and the thimble by which it is ignited.

The arrangement for time is contained in the upper part of the fuze. The column or ring of fuze composition is in the body of the fuze, and a movable metal collar and clamping nut is fitted over it. A collar of mealed powder is pressed into a recess in the inner surface of the movable metal collar. The collar is kept in its place by a nut which screws on to the neck.

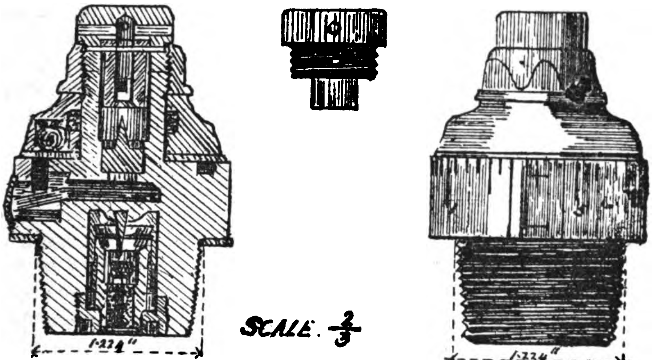
Into the top of the fuze is screwed the thimble of gun-metal which contains a hammer kept in position by a suspending wire: the hammer contains a patch of cap composition, and below it is a steel needle.

The lower portion of the fuze is hollowed to receive a second detonating arrangement.

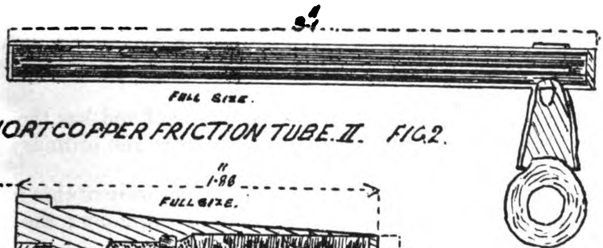
The thimble is not inserted in the fuze until the moment of loading.

The fuze is set by loosening the nut and turning the collar till

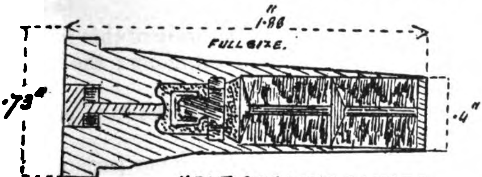
PL. XII.



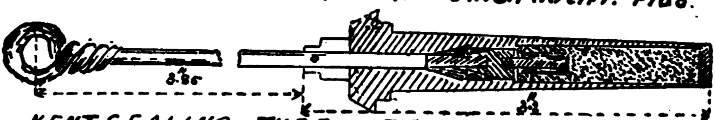
TIME and CONCUSSION FUZE. I. FIG. 1.



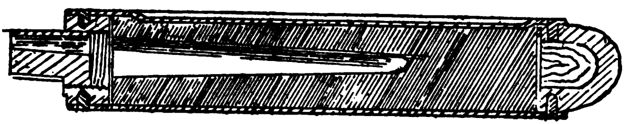
SHORT COPPER FRICTION TUBE. II. FIG. 2.



VENT SEALING PRIMER FOR 6-INCH ROCKET. FIG. 3.



VENT SEALING TUBE. FIG. 4. SCALE 2/3.



SECTION OF WAR ROCKET. FIG. 5.

[To face p. 64.

TABLE IX.—FUZES FOR USE WITH RIFLED ORDNANCE.

Nature of Ordnance.	Percussion Fuze.	Time Fuzes.
B.L.		
13·5-inch gun	..	Armstrong medium time and concussion.
12-inch „	..	Do.
10-inch „	Direct action.	Do.
9·2-inch „	Do.	Do.
8-inch „	Do.	Do.
6-inch „ Marks II. & III.	Do.	Do.
6-inch „ 80 cwt. (80-pr.).	Do.	Do.
5-inch „	R.L.	Do.
4-inch „	Do.	Do.
22-pr. „	Do.	Do.
12-pr. „	Do.	Do.
R.B.L.		
7-inch gun	Direct action.	15 seconds, with detonator, Mark III.
40-pr. „	R.L.	Do.
20-pr. „ L.S.	B.L. plain.	Nil.
20 pr. „ S.S.	R.L.‡	Armstrong E,† and 15 seconds, with detonator, Mark III.‡
12-pr.§ „	B.L. plain.	Armstrong E.†
9-pr.§ „	Do.	Do.
R.M.L.		
17·72-inch gun	Pettman G.S.	15 seconds M.L.
16-inch „	Do.*	Do.
12·5-inch „	Do.*	Do.
12-inch „ 35 ton	Do.*	Do.
12-inch „ 25 ton	Direct action.	Do.

* Not set in action by the full charges of these guns.
† For segment shell, S.S. only.
‡ For common shell, S.S. only. The segment shell for S.S. takes the B.L. plain fuze.
§ Shrapnel shells for 12-pr. and 9-pr. R.B.L. guns have the G.S. fuze hole, and take 5 and 9 seconds B.L. or 15 seconds wood time with detonator, also R.L. percussion fuzes.

FUZES FOR USE WITH RIFLED ORDNANCE—*continued.*

Nature of Ordnance.	Percussion Fuze.	Time Fuzes.
R.M.L.		
11-inch gun	Direct action.‖	15 seconds M.L.
10-inch "	Do.	Do.
10·4-inch gun	Do.	Do.
9-inch "	Do.	15 seconds, with detonator, Mark III. *a*
8-inch "	Do.	15 seconds M.L.
8-inch howitzer, 70 cwt. ..	Do.	¶
8-inch " 46 " ..	Do.	¶
7-inch gun	Do.	15 seconds M.L.
6·6-inch "	Do.	15 seconds, with detonator, Mark III.
6·6-inch howitzer	Do.	¶
80-pr. gun	Do.	15 seconds M.L.
64-pr. "	Do.	Do.
6·3-inch howitzer	Do.	Nil.
40-pr. gun	R.L.	15 seconds, with detonator.
25-pr. "	Do.	15 seconds M.L.
16-pr. "	Do.	Do.
13-pr. "	Do.	15 seconds, with detonator, Mark III.
9-pr. "	Do.	15 seconds M.L.
7-pr. "	Do.	Do.
7-pr. " 400 lbs.	Do.	Armstrong small and medium time and concussion.

‖ Direct-action fuzes must not be used in guns loaded by hydraulic rammer, such guns should be supplied with Pettman G.S. fuzes for battering charges only; the G.S. fuze is not set in action by the full charge.

¶ Pattern not yet decided. A 15 seconds time fuze with detonator 0·012-inch wire may, however, be supplied if necessity arises.

a The 15 seconds M.L. wood fuze can be used for shells not fitted with gas-checks.

NOTE.—The 15 seconds wood time fuze with detonator and 0·042-inch suspending wire (Marks I. and II.) may be used up in the following R.M.L. guns:—13-pr., 40-pr., 6·6-inch, 9-inch. It may also be used in 9-pr., 16-pr., and 25-pr. R.M.L. guns in lieu of the M.L. wood time fuze.

the arrow points to the desired length of composition, which is marked in inches and tenths of inches.

On the shock of discharge the detonator at the top acts, and the fuze composition is ignited, and burns until the flame reaches the point at which the magazine behind the arrow is set, when the flash communicates with the collar of mealed powder in the movable collar, and thence passes by a channel which is driven with mealed powder and pierced like a tube, and so through the bottom of the fuze.

If, during the flight of the shell, it strikes anything, the percussion arrangement in the lower part acts at once.

The fuze possesses great advantage over a wood time fuze which when once bored cannot be altered: also it can be set to any time of flight within its limits of burning: further, the shell can be fuzed and the fuze set beforehand, the thimble or detonator being screwed in at the moment of loading.

There are three descriptions of the fuze, "small," "medium," and "large." The small size is driven with 4 inches of fuze composition burning 7·6 seconds at rest; it is used with the 7-pr. of 400 lbs. The medium size has 5 inches of composition burning 11·1 seconds at rest; it is used with the new B.L. guns. The large size burns 14·65 seconds at rest.

The fuzes and thimbles are packed in separate cylinders.

Fuzes for Smooth-bore Ordnance.

Natures.—The time fuzes are the common fuze, diaphragm shrapnel fuze, and the large and small mortar fuzes: the percussion fuze used is Pettman's land-service fuze.

In all the time fuzes the priming at the head is protected by a tin cap and disc of pasteboard which are removed by means of the tape when the shell is placed in the gun or mortar. The common fuze burns for 10 seconds and has two powder channels: the diaphragm shrapnel also has two powder channels and burns for 5 seconds; they are graduated to half seconds or tenths of inches.

In the large mortar fuze there are 6 inches of fuze composition, burning for 30 seconds: the figures on the fuze refer to the inches of composition, but by adding a cipher they will refer to the general half-second unit: the fuze reads to seconds only: the first mark for boring commences at 3 inches or 15 seconds.

The small mortar fuze burns for 15 seconds and contains 3 inches of fuze composition: the first mark for boring commences at 1 inch or 5 seconds. Neither of these fuzes have powder channels.

All the time fuzes for S.B. ordnance take the common gauge except the large mortar which has the mortar gauge.

Pettman's L.S. fuze is used with common shell of common gauge, but the hole must be tapped throughout to receive this fuze, which is indicated by a cross cut on the plug.

The fuze is very similar in construction and action to the G.S. fuze, with the exception that there is no brass ball which was unnecessary with S.B. guns, on account of the detonating ball always being released from its pivots by the unsteady motion of the shell. There is also a shoulder to the fuze. The fuze acts on direct impact, but is not intended to act on graze.

Friction Tubes.

Description.—In order to ignite the charge in pieces of ordnance having forward or radial vents, friction tubes are used, made of copper for land service and of quill for the navy, copper tubes being liable to injure the men's feet and also to rebound from the overhead beams or tops of turrets.

There are four descriptions of copper friction tubes, viz. long, short, special for 7-pr. R.M.L. guns, and special long with wire loop.

The short tube is 3 inches in length, and is used for guns under the 7-inch: it consists of a copper tube driven with mealed powder, and pierced with a central hole. The top is closed with shellac putty, the bottom with a paper disc. At $\frac{1}{4}$ inch from the top a hole is bored and in this is soldered a short nib-piece or cylinder which is further secured by copper wire. The nib-piece contains a copper friction bar roughened on both sides and smeared over with damped detonating composition: one end of it is slightly turned up and the projecting end terminates in a vertical loop. The nib-piece is pinched down so as to press on the sides of the friction bar. The lanyard is hooked to the vertical eye, and on pulling it sharply, the friction bar is drawn out, igniting the detonating composition, and firing the tube: the hole down the centre of the mealed powder causes the tube to act instantaneously. (Pl. XII. Fig. 2.)

The "long" tube is 5 inches in length and is used with 7-inch guns and upwards; it is similar in other respects to the short tube. The special tube for 7-pr. R.M.L. guns is 2 inches in length.

The special long with wire loop is the long tube with a wire loop attached: to the end of the loop a small lanyard is hooked and hitched on to the carriage in order to prevent the tube flying about.

Tubes in general.—The eye of the friction bar in the older

patterns of tubes is horizontal. The present pattern is more convenient for packing, and also the tube is on firing less likely to be drawn out of the vent.

All tubes have a diameter of $\frac{2}{10}$ inch, that of the vents being in all cases $\frac{2}{9}$ inch.

They are packed in zinc cylinders which are on no account to be placed in a magazine. A tin tube box holding 100 tubes is used for the service of garrison guns: leather tube pockets being used for field service.

Quill tubes are similar in their action to copper ones: to the head of the tube is fastened a leather loop which is passed over the friction-tube pin, that is screwed into the gun when issued for sea service; its object being to support the head when the pull of the lanyard comes on it.

Vent-sealing Tubes.

Description.—These tubes are used with R.M.L. guns having axial vents, and with the earliest patterns of the new B.L. guns; the discharge of the tube and the gas to the direct rear would otherwise be inconvenient and dangerous.

They are either frictional or electric. (Pl. XII. Fig. 4.)

The vent-sealing friction tube is made of steel copper-plated: it is bored out to receive the wire for attachment to the lanyard, the steel closing-cone, friction bar, charge of powder, &c.: the exterior of the body is tapered to fit the vent of the gun: at the top of the head is a small projection fitted with a safety pin which passes through the wire for the lanyard. The inner end of the wire is secured and soldered into the upper end of a steel cone, and the lower end of the cone is fitted with a copper friction bar. The friction bar passes through two brass discs which are fixed in position in the centre of the tube, and two small oval copper tubes are placed over the friction bar, being filled with detonating composition and compressed over the bar. The lower end of the tube is filled with R.F.G. powder, and the end closed with shellac putty.

On firing, by pulling the lanyard attached to the wire the safety pin is sheared, and the friction bar is drawn through the detonating composition in the copper tubes, which are retained in position by the brass discs. The steel cone is forced into the corresponding cone at the upper end of the tube, and prevents any escape of gas: the body of the tube being of steel is expanded and fits the vent tightly.

The electric vent-sealing tube is similar in external appearance; two insulated copper wires are inserted through the head, and in

the centre of the tube is a platinum bridge surrounded by priming composition.

Special vent-sealing electric and mechanical primers are used with the 6-inch 80-cwt. B.L. gun: in the latter the tube is fired by a needle in the vent bolt striking the head of a steel firing pin which fires a cap (Pl. XII. Fig. 3).

The action of a vent-sealing tube depends on an accurate mechanical fit, and therefore before it is inserted the vent must be carefully cleaned with the rimer provided. The lanyard should be held as nearly as possible in prolongation of the axis of the gun, and more of a jerk is required than with the ordinary friction tube.

Percussion primers and vent-masking slides are used with all B.L. guns of 5-inch and upwards with the exception of the earlier marks of a few natures. The pull of the lanyard releases a hammer which fires the cap of the primer.

Miscellaneous.

Abel's Electric Tube.—This tube is used for firing guns at proof and experimentally. The head is oval and in it is a primer containing insulated wires, the lower ends of which are bared and imbedded in a detonating composition: it has two eyes, in which are inserted the wires from the battery; it is united to a long quill tube of the ordinary pattern.

Electric fuzes and detonators are used for exploding charges of gun-cotton and gunpowder in field and siege operations: in most of them the passage of the current heats a bridge of platinum wire which ignites a priming of gun-cotton. Electric detonators must not be forced into gun-cotton slabs or primers; a wooden rectifier is first entered into the hole for the detonator.

Detonator for safety fuze is used for hasty demolitions. It consists of a tin tube containing fulminate of mercury; to this is attached a brass tube large enough for a piece of safety fuze to enter: a strand of quick match conveys the flash from the safety fuze to the fulminate of mercury. The detonator is inserted in a hole in the gun-cotton primer and the safety fuze lit by hand, burning a sufficient time to allow the operator to get clear. It is issued to horse artillery and cavalry in conjunction with gun-cotton primers and slabs.

Safety fuze is made of flax with a column of fine powder in the middle: for use under water it has a guttapercha covering: it burns 1 yard in a minute.

Instantaneous fuze burns 30 yards a second: it resembles safety fuze, but contains two or more strands of quick match in place of

powder: it is chiefly used in the navy for firing hand charges, and is then fired in a pistol.

Quick match is made of cotton wick boiled in a solution of mealed powder and gum. Uninclosed, it burns about 1 yard in 13 seconds; but inclosed in a tube of any kind, it burns almost instantaneously.

Slow match is made of pure hemp twisted and boiled in water and wood ashes, or in a solution of water and saltpetre: it burns 1 yard in 8 hours, and is used for lighting portfires, &c.

Common portfire consists of a cylinder of stout brown paper filled with a composition of mealed powder, saltpetre, and sulphur: it burns for 12 or 15 minutes.

Wedge wads are used with all R.M.L. guns mounted on traversing platforms, in order to prevent the projectile moving to the front in running up: they consist of two wooden wedges connected by a piece of cane, and are in two sizes; the larger for 9-inch guns and upwards, the smaller for guns below 9-inch.

Tin cups are used with 7-inch R.B.L. guns to secure a gas-tight joint at the end of the bore: they have a rim, which is pressed against the sides of the bore by the explosion of the gas. There is a central hole for the passage of the flash of the tube: they are used in the lower natures of R.B.L. guns at practice only. For the side-closing 40-pr. the tin cup has a rectangular slot cut in its centre.

Vent-piece primers are used with 40-pr. and 7-inch R.B.L. guns: they consist of tubes of leather paper $2\frac{1}{2}$ inches in length, driven with mealed powder and pierced like a tube: three strands of worsted are attached on the outside to keep them in position in the vent. They are necessary in consequence of the vents of these guns having two directions.

Hale's War Rockets.

Description.—The natures of war rockets in the Service are 9 and 24-prs. Their construction is as follows: The head is of cast iron plugged with wood and riveted on to the body; the latter is made of Atlas metal, bent into a cylindrical form, and corrugated to give a better hold to the composition. The composition is made of the ingredients of powder, but in different proportions: it is pressed into pellets, and each pellet is pressed separately into the case under hydraulic pressure. The base is closed by a cast-iron ring, into which is secured the tail-piece; the latter is of cast iron, and contains three conical vents; the vents are cut away on one side, so that the gas on issuing meets with resistance on that side only where they are prolonged, and

thus rotation is given to the rocket. The pressure of the gas against the head gives the rocket its forward motion. A conical hole is bored up the middle of the composition, so that the gas is quickly generated. The tail-piece and vents are protected by canvas, which is removed before firing. (Pl. XII. Fig. 5.)

Rockets are painted red: 300 24-pr. rockets are issued to each unit of a siege train.

They are fired from a trough made of sheet iron, and supported at the rear by three legs of wrought-iron tubing, two short ones opening right and left, and one long one extending to the front beneath the trough. On the front one runs a bar connected with the trough, by which elevation is given up to 15° for the 9-pr., and 25° for the 24-pr. The average range at 15° is about 1500 yards, but the range and deviation of rockets vary considerably.

Disabling Guns by Gun-cotton.—This operation, when required, forms part of an artilleryman's duties, and is done as follows:—

In the case of heavy guns when time is immaterial, the vent is plugged up and the gun up-ended. The insulated wires from the battery are inserted into the detonator, and the latter is then placed into the hole in a dry primer of gun-cotton weighing one ounce, no force being used. The dry primer with detonator is then inserted into the perforation in a 1-lb. slab of gun-cotton, either wet or dry, which is immaterial. This, together with another 1-lb. slab, is placed in a waterproof bag, the neck of which is then choked with twine and plastered with indiarubber solution. The whole is lowered to the bottom of the bore, which is then filled up with water. The operators should retire to a safe distance and explode the charge by connecting the wires with the binding screws of the exploder and then turning the handle rapidly.

In the case of siege or field guns when time is of importance, the 1-lb. slab of gun-cotton containing the primer and detonator is tied on the chase of the gun with twine. The safety fuze with which the detonator in this case is provided is lit, and burning for about 45 seconds fires the charge. In the case of 64-pr. guns and upwards, two slabs of gun-cotton would be used. A projectile should if possible be rammed down the bore to prevent the gun being afterwards used to fire bullets, &c.

PART III.

CARRIAGES, MACHINES, AND MISCELLANEOUS.

CHAPTER VIII.

FIELD AND SIEGE CARRIAGES.

Travelling Carriages.—Field and siege pieces are mounted on travelling carriages made of wrought iron, and in the case of the 13-pr. gun carriage of steel. Wrought iron is being generally replaced by steel for travelling carriages.

FIELD CARRIAGES.

A field carriage consists of two bracket sides, connected by two transoms, collar bolts, and a trail piece: an axle-tree bed with axle-tree, and field wheels 5 feet in diameter, having a wheel track of 5 feet 2 inches: axle-tree boxes with lids forming seats are fitted on either side. The 9-pr., 16-pr., and 25-pr. R.M.L. guns are mounted on field carriages.

13-*pr. Gun Carriage.*—This carriage has brackets of steel plate riveted to an angle-iron frame. The axle-tree bed is of light steel plate and with the steel axle-tree forms a bowstring girder for vertical strength. Tensile stays connect the axle-tree arms with the trail to resist the horizontal strain. The elevating gear consists of an arc attached to the cascable of the gun having teeth on the rear edge in gear with a pinion on the same spindle as a worm wheel which is driven by a worm with a hand wheel placed inside the right bracket.

The axle-tree seats are supported on six springs; there are no boxes, but two case shot and two cartridges can be carried in fittings on the brackets.

SIEGE CARRIAGES.

These are similar in general construction to field carriages, but are of necessity made stronger; they have two sets of trunnion holes for firing and travelling, and the splinter-bar of the limber is fitted for four-horse draught.

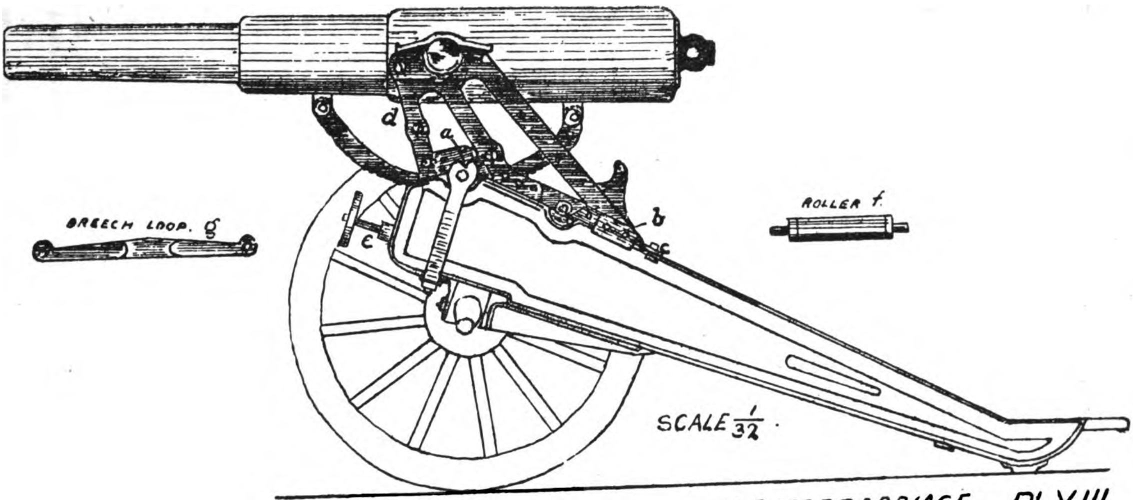
Overbank Carriages.—With the carriages of the 25-pr. and

40-pr. guns in the siege train a wrought-iron overbank top is used: each top is fitted with two sets of trunnion holes and is secured to the carriage by four strong vertical bolts (*a*), clips (*b*), and bolts (*c*); by this means the gun can be fired over a 5-foot 6-inch parapet (Plate XIII.). The fittings for these carriages consist of the top carriage (*d*), a special elevating gear (*e*), a roller (*f*), and breech loop (*g*) for shifting the gun from the firing to the travelling trunnion holes, and a laying step. The elevating arc is secured at each end to plates fixed under the gun. Clerk's platforms are used with the above carriages.

Clerk's platform consists of two inclined planes of fir (sloping 3°) fitted on their inner sides with a riband and an iron movable stop in front and rear to keep the wheels on the planes. The trail plank is strengthened with iron. The transoms are laid flush with the surface of the ground at right angles to the line of fire, two in front, one at the centre, and one at the rear. The inclined planes are laid on them, being pivoted to the front transom. The trail plank is placed between the side pieces with its iron-shod portion to the front.

Hydro-pneumatic Carriage for 6·6-*inch Gun*.—In this carriage, which is used in the siege train, the force of recoil is utilised in bringing the gun down from its firing position above to the loading position below the parapet. The carriage consists of two bracket sides, a transom, trail eye, solid axle-tree and wheels. The gun rests in a crutch on the top of a hollow steel ram, which slides in a cylinder inside of an outer chamber. This outer chamber is of gun-metal, and has trunnions at its base which rest in bearings in the brackets. At the position of the trunnions the cylinder and chamber are connected by valves. When the gun is in the loading position the ram fills the cylinder, the chamber being filled with compressed air and liquid: on opening the by-pass valve in the right trunnion connecting the chamber and cylinder, the ram is forced upwards and the gun by this means raised to the firing position. On recoil the descending ram forces the liquid back into the outer chamber through the non-return valve in the left trunnion. An air-pump is supplied for charging the cylinder and replacing any loss by leakage; the pipe connecting the air-pump is attached when required to a screw valve in the left trunnion, a pressure gauge can also be attached to an opening there. The gun is also supported by radial arms pivoted to the axle-tree, the arms have long slots to carry the trunnions in either the travelling or firing position. Retaining chains are fixed at the top of the radial arms.

Howitzer Siege Carriages.—The travelling siege carriages for howitzers are of ordinary pattern, fitted with an hydraulic buffer for



40-PR. OVERBANK TOP FOR TRAVELLING SIEGE CARRIAGE. PL. XIII.

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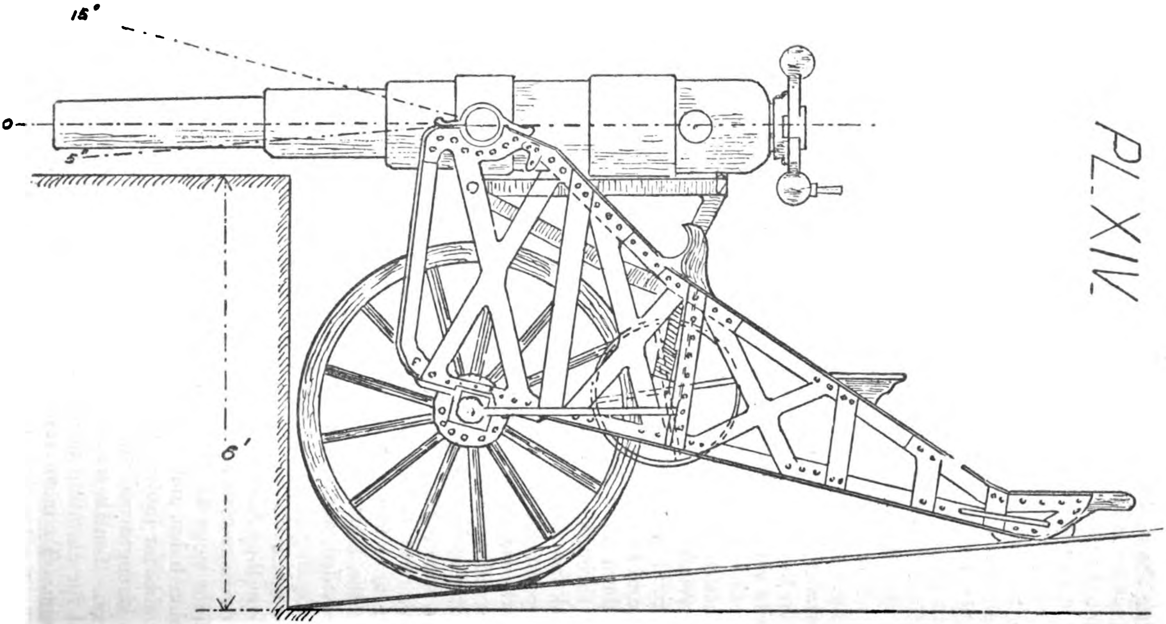

WROUGHT IRON TRAVᴳ CARRIAGE FOR 40-PR. R.B.L. SIDECLOSING GUN.

[To face p. 75.

checking the recoil. The buffer consists of a wrought-iron cylinder with caps screwed on each end, and a piston rod with piston. A trunnion ring with trunnions is shrunk on the centre of the cylinder, and there are also trunnions on the front cap; the latter are connected with the centre trunnions by a tie bar on either side. The end of the piston rod is fitted with a link by which it is shackled to the anchoring arrangement. When in action, the centre trunnions are suspended from the axle-tree bed by rods, and are connected by bars to a bolt attached to the trail. For travelling, the rods are detached from the trunnions and the buffer is raised and secured under the axle-tree bed by means of chains. The total weight of the carriage, buffer, and wheels for the 6·6-inch howitzer is 32 cwt., and for the 8-inch howitzer 45 cwt. The size of the holes of the piston of the buffer is 0·35 inch: the quantity of oil in the buffer is varied to suit the different velocities of recoil, owing to varying charges being used with howitzers.

Anchoring Arrangements.—The anchorage is laid during the construction of the battery, and consists of an iron tie rod 12 feet long, having at one end a shackle and bolt to connect it with the piston rod; the other end passes through and is connected to an oak beam 10 feet × 9 inches × 9 inches. In front of this oak beam there is another shorter one to prevent the tie rod being forced through the large beam when running up the howitzer. The oak beam must be laid so that the tie rod will be parallel to the slope of the platform, and the eye of the tie rod must project inside the revetment, conveniently for shackling up.

Travelling siege carriages fitted with hydraulic buffers are used on a double-decked wood ground platform furnished with wheel guides, wheel plates, and trail plank. The platform consists of two layers of 3-inch fir planks, the bottom layer parallel to the line of fire: four transverse planks are placed under the bottom layer: the layers are connected by coach screws. Two hurters are provided, with a space of 2 feet between them to prevent the buffer fouling them. The platform is laid at a slope of $\frac{1}{24}$, with a clear space of 1 foot between it and the foot of the interior slope.

Travelling Siege Carriage for 40-pr. R.B.L. side-closing Gun.—This carriage consists of two brackets, trail eye, first-class axle-tree and light siege wheels. It is fitted with elevating gear, travelling trunnion holes, and a step for laying, also a folding step on the right side for loading purposes. The brackets are frames of angle iron, strengthened by bar- and plate-iron stays forming lattice girders. Tensile stays join the axle-tree to the trail. The hand wheel for elevating is on the outside of the right bracket of the carriage. To move the gun to or from the travelling trunnion holes, a wood roller is placed in bearings on the brackets, and

tackles are attached to loops on the front of the brackets. The carriage is constructed to fire over a 6-foot parapet. The height to axis of trunnions in the firing position is 6 feet 5·5 inches, the total weight is 25½ cwt. (Plate XIV.)

CHAPTER IX.

CARRIAGES AND PLATFORMS FOR HEAVY ORDNANCE.

Carriages for Heavy Guns.

7-inch R.M.L. guns and upwards are mounted on wrought-iron carriages which slide on traversing platforms of wrought iron. The carriages are all now made of double-plate construction, and serve either for a casemate or an open battery.

The carriage consists of two brackets, a bottom plate, and a transom in front; each bracket is a frame with a plate riveted on either side of it. The brackets and transom stand upon the bottom plate to which they are secured. Guides of angle iron are riveted along the under surface of the bottom plate, which, fitting between the sides of the platform, ensure the carriage sliding in a true position during recoil or in running up. The carriage has four gun-metal rollers running upon iron axles: the rear ones are connected by the eccentric shaft, the ends of which are made hexagonal for the reception of sockets to take iron-pointed levers for the purpose of bringing the rollers into play in running up.

On the outside of each cheek an iron stop is bolted, against which on recoil the sockets can bear, and so prevent the rear rollers coming into play; the iron stops also take the bearing of movable pawls (attached to the sockets) when running back. The eccentric shaft has holes for the reception of the iron-pointed levers in the event of the sockets being injured.

The shaft and rear rollers can be removed by taking out the rear bolts of the drop plates and turning the latter upwards.

Elevating Gear.—In all the newer pattern carriages except that for the 7-inch R.M.L. gun, the worm-wheel elevating gear is used. It consists of an elevating arc attached to the gun, and working up and down between a friction roller or a metal guide and a pinion: a worm shaft secured to the bracket of the carriage and worked by a hand wheel, acts on a worm wheel, and so through the intervention of a pinion or pinions on to the elevating arc.

The elevating gear is fitted to both sides of the carriage, but either side can be thrown out of gear if required. In 10, 11 and

PL. XV.

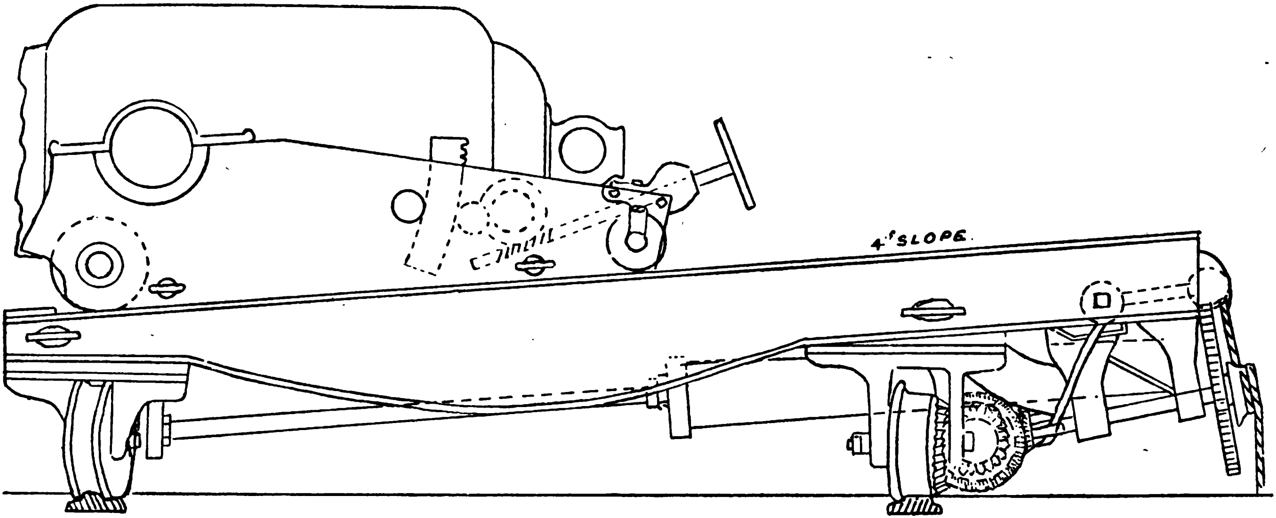

FIG. 1. LOW CASEMATE CARRIAGE AND PLATFORM FOR 10-INCH R. M. L. GUN.

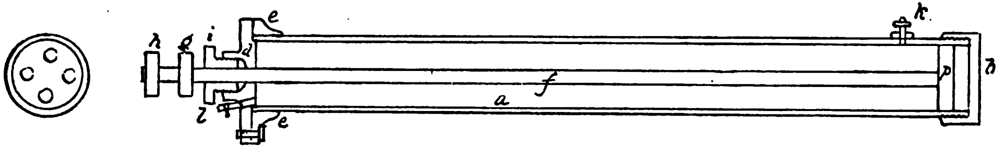

FIG 2. SECTION OF HYDRAULIC BUFFER.

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12-inch carriages the worm wheel is fitted with a friction cone (Plate XV.).

Capstan-head elevating gear is found still in the older pattern of carriages. The spindle of the pinion passing through the bracket of the carriage has on its outer end the capstan head and jamming lever: the capstan head has holes in its circumference, by which by means of iron-pointed levers it is turned, and the elevating arc of the gun moved: the jamming lever on the spindle outside the capstan clamps the pinion when required.

Fittings.—Cap-squares are keyed over the trunnion holes, the latter have a lining formed by metal trunnion plates.

Fittings for Hydraulic Buffer.—A bracket is bolted to the under side of the bottom plate of the carriage in front, having in it an oval hole, through which the piston rod passes. Two clip plates are bolted underneath the bottom plate, which hold the carriage to the platform during recoil, and prevent the piston rod being bent.

Before dismounting a carriage it is necessary to remove the clip plates and to disconnect the piston rod from the bracket: a carriage fitted with the hydraulic buffer must never be fired from unless it has clips.

Fittings for Elswick Compressor.—If the carriage is fitted for the Elswick compressor, an opening is cut in the bottom plate through which seven plates hang resting on a supporting bar laid across the bottom plate and on the transom of the carriage. A compressing shaft passes through the right bracket of the carriage and has cut on it right and left handed screws, which separate or bring together two nuts, the latter acting on rocking levers which either compress the plates or take off the compression. The amount of compression is regulated by the adjusting shaft on the left side of the carriage, which alters the position of the left-hand nut on the compressing shaft.

Scott's Carriage.—This carriage is used with 10-inch and 12·5-inch R.M.L. guns: it has low brackets, the bottom of the carriage forming a well which fits between the sides of the platform when the carriage is mounted: the well admits of high elevation being given to the gun, which the low brackets would prevent.

12·5-*inch Carriage.*—In the 12·5-inch carriage the eccentric axles for the rear rollers are worked by an hydraulic jack attached to the inside of the left bracket, its ram being keyed to a crank upon the shaft.

The carriage is fitted with nipping gear, being run in or back by two endless chains in the platform: in order to attach the carriage to these chains when required, there are two plates with projecting teeth (sprocket plates) on each side, one for each chain, connected by a shaft inside the well of the carriage; these plates

are lowered by a lever outside the carriage, when their teeth catch in the endless chains; the chains pass through brackets beneath the carriage, which hold them up to the sprocket plates when the latter are forced down.

The piston rod of the hydraulic buffer is secured to the front transom, the rod being in tension and the buffer secured under the carriage.

Preventer gear is added to secure an efficient check in running up, thus protecting the elevating gear from damage.

Small Port Carriages.—In small port carriages means are supplied for altering the height of the trunnions of the gun in order that it may be fired through a small port with considerable elevation or depression.

The brackets are formed each with a slot to allow the trunnions of the gun to be moved up or down; the bottom plate has a hole cut in it to receive an hydraulic lift which acts under the trunnion coil of the gun and raises or lowers it as desired. There is a screw lift under each trunnion to take the weight off the lift on firing.

Carriages of this nature have been made for the 10-inch and 12·5-inch guns.

Carriage for 100-ton Gun.—The carriage for the 100-ton R.M.L. gun is of the usual double-plate construction, and is fitted with an hydraulic elevating press of gun-metal supported on trunnions fastened on brackets in rear of the carriage.

The platform is of the ordinary wrought-iron girder construction, with an inclination of 4 degrees, and so pivoted that when the gun is run up nearly all the weight is taken on the pivot for facility of traversing. It is fitted with two recoil presses and with hydraulic traversing and loading gear.

Traversing Platforms for Heavy Guns.

Wrought-iron platforms for double-plate carriages are made "casemate" and "dwarf," differing only in their height; the former being used in casemates and therefore made low, the latter are for use in open batteries and are made higher.

Casemate Platform (Pl. XV.).—A casemate platform consists of two sides of girder iron, and of two or more transoms. A top plate is bolted over the front ends of the sides; there are besides two bottom plates, two truck plates, four flanged feet and four trucks; also a diagonal stay of 1-inch plate, formed of a centre piece to which four arms are welded. The platform is 15 feet long and has a slope of 4 degrees, the latter being obtained by an

angular packing piece of iron placed between the rear truck plate and the sides.

A stop is formed for the carriage when run up by a piece of angle iron with a backing of wood, and on them are four india-rubber buffers; two stops are also placed in rear for the carriage on recoil.

Eye-bolts for tackle are bolted in front and rear on each side; a movable platform board is fitted across the rear of the platform.

Fittings for Elswick Compressor.—When the platform is fitted for the Elswick compressor, six compressor bars are hung in supporting brackets lengthways between the sides, and a tripper is bolted to the right side near the front.

Fittings for Hydraulic Buffer.—When fitted for the hydraulic buffer a bearing plate is bolted across the platform for the support of the front of the buffer, and two holding-down bands which lie over the buffer are bolted, one to the bearing plate and the other to the rear bottom plate.

Hydraulic Buffer.—The buffer consists of a cylinder closed by a cap and cover: in the cover is a hole through which the piston rod passes, a perfectly tight joint being secured by a packing gland and packing of tow.

The piston rod, on the rear end of which is the piston, has two nuts screwed on its front end, between which it passes through the oval hole in the bracket of the carriage, and thus the carriage on recoil forces the piston rod back. In the piston are four holes varying in size according to the amount of resistance to recoil required, and therefore the heavier the gun the smaller are the holes made. For use, the buffer is filled with 12 gallons of oil which can be tested by measuring the depth at the filling hole on the top of the cylinder at its rear end; the measurement should be $4\frac{5}{8}$ inches when the carriage is run up. A small space is left in the cylinder for air, which acts as an elastic cushion, and also leaves room for the piston and rod (Pl. XV Fig. 2). The resistance offered by the oil increases with the velocity of the piston, and *vice versâ*; there is but slight resistance therefore when running up.

Traversing Gear.—9-inch platforms and upwards are fitted with traversing and running-back gear, set in motion either by two winch handles on a cross shaft parallel to the rear transom, or by one handle on a spindle projecting from the rear of the same transom.

The platform is traversed or the carriage run back by turning the handles, the part of the gear acting on the trucks being connected or not, as desired. For this purpose a clutch pinion is provided, moved by a lever which is retained in the required

position by a keep pin fitting into a hole in a guide under the left of the platform.

When the clutch pinion is thrown forward into gear the trucks revolve on the winch handles being turned. When it is thrown back out of gear, turning the handles merely causes a bollard to revolve, round which is passed the fall of the running-back tackle, which is held on to, and so the carriage runs back.

Fittings.—A folding pointer is attached to the right rear of platforms for use with a graduated arc on the floor.

In platforms for 10-inch guns and upwards the sides are made fish-bellied for additional strength, and snatch blocks are fitted to the front of the platform to give a lead to the running end of the fall of the hoisting tackle.

The casemate platform, to suit Scott's low-pattern carriage, is made of greater height than the ordinary casemate to make up for the lowness of the brackets of the carriage.

The casemate platform for the 12·5-inch gun is fitted with rack traversing and chain running-back gear worked by the same winch handles.

Dwarf Platform.—Dwarf platforms in general construction are similar to casemate, but are made of greater height, which is obtained by using larger trucks and by additional packing pieces between the truck plates and sides of the platform.

Trucks.—The trucks of wrought-iron platforms for 10-inch guns and upwards are made of steel with bushes of phosphor bronze.

Special Carriages and Platforms.

64-pr. and 7-inch Carriages.—The 64-pr. converted gun of 58 cwt. and 7-inch R.B.L. guns are now mounted in certain positions on wrought-iron sliding carriages: the old-pattern wood platform being used with them altered so as to take the hydraulic buffer or Elswick compressor.

40-pr. R.B.L. Carriage.—A wrought-iron sliding carriage and platform has been constructed for this gun: the carriage is supported on ten rollers permanently in action, and is fitted with an hydraulic buffer secured under the bottom plate.

The carriage can be secured when run back if required. The piston rod is attached to the front of the platform. The trucks are of steel and the racers of gun-metal; it will fire over a sill 2 feet 3 inches high with a depression of 15 degrees.

32-pr. B.L. Carriage.—The 32-pr. 42-cwt. B.L. smooth-bore gun is mounted on a wrought-iron sliding carriage and platform, made to a slope of 10 degrees to enable the carriage to run out without the use of rollers; the carriage is single plate, and is

arranged for firing over a 2-foot 3-inch parapet; it is fitted with the ordinary hydraulic buffer.

Moncrieff Carriage.—In Moncrieff carriages the force of recoil is made use of to bring the gun down to a position beneath the parapet, where it is retained until loaded; the stored-up force of recoil is then brought into play to raise the gun again to its firing position above the parapet, so that in the loading position the detachment and gun, &c., are screened from direct fire.

The gun is placed in a carriage and elevator, or in an elevator alone, and a counterweight of metal is placed at the opposite end of the elevator to that in which the gun lies. The elevator rolls back on the platform owing to the force of recoil, and in so doing the counterweight is raised: when the weight is permitted to fall, the elevator rolls forward on the platform again, and the gun is raised. In the latest pattern the gun rests on the elevator, and there is no carriage proper.

64-pr. 7-inch M.L. and B.L., and 9-inch M.L. guns have been mounted in certain positions on these carriages, in which cases special pits are constructed to receive them.

Wooden Carriages and Platforms.

There are still a certain number of these in the Service, of which the principal are the following:—

Travelling Siege Carriage for 40-pr. R.B.L. gun.—The trail is of oak, either in one or sometimes in two pieces joined longitudinally; it is fitted with a trail plate and eye for attachment to the limber: the brackets are of oak or elm, the axle-tree bed of oak; the axle-tree is the O.P. siege, and it has siege wheels, with a wheel track 5 feet 2 inches.

The carriage is fitted with a traversing arrangement consisting of a metal saddle carrying the gun in trunnion holes and secured by cap-squares. This saddle slides in dovetailed slots in the trunnion plate, and is traversed by means of an iron lever pivoted on the trail, the lever being worked by a traversing screw and hand wheel.

The carriage has firing and travelling trunnion holes, a 14-inch gun roller of sabicu being used for shifting the gun. In travelling, the elevating screw and its handle are carried in leather pockets on the right of the carriage, and the gun is secured by straps. The screw is the ratchet-head and lever pattern, the nut for which is square and rests in a metal socket in the trail. The trail is fitted with four handles. The limber has a straight pintail with keep chain, and is adapted for 4-horse draught.

Garrison Standing Carriages.—These are chiefly used for 64-pr. R.M.L. guns and 32-pr. S.B. guns.

A standing carriage consists of two brackets of oak or teak, two axle-trees, a transom, and four trucks.

In the brackets are cut trunnion holes and steps to serve as fulcra for handspikes in elevating.

The transom is of oak or teak, the axle-tree of oak, the body being rectangular, the arm cylindrical; the trucks are of cast iron, the front ones 19 inches and the rear 16 inches in diameter, in order to compensate for the slope of the platform on which the carriage stands.

Belonging to the carriage are a large and small quoin of sabicu, a stool bed of wrought iron, and an elevating screw of the ratchet-head and lever pattern. In order to check the recoil when necessary Allen's brake is used, which consists of an iron-shod wedge attached to the bracket in rear of each front truck, and also to the axle-tree in such a manner that the wedge rests on the ground in rear of the truck, and on recoil is overridden by the truck; if not required to be used, the wedge can be secured back by a lanyard.

Rear Chock Carriages are similar in general construction to standing carriages, but in place of the rear axle-tree and trucks they have a block of oak or sabicu, by which the recoil of the gun is decreased.

Sliding Carriages differ from standing carriages in having blocks of oak or sabicu in place of axle-trees and trucks to take the bearing on the platform.

Two 8-inch metal rollers to facilitate running up are secured to the front block. An eye and notch for pawl is fixed to the rear of either bracket to take a truck lever for running up.

Wood Traversing Platforms take all natures of sliding carriages. They are either dwarf or casemate, differing only in their height, and one can readily be converted into the other. The platform is of teak, and consists of two sides with cheeks, three transoms, one head block, four flanges, and four trucks.

The Wooden Compressor for these platforms consists of two cheeks held together by guide bolts which fit tightly in one cheek but slide in and out of the other: the cheeks are brought close together or kept apart by moving a lever handle which acts upon an iron eccentric fitted between the cheeks: the lever is on the right of the platform, and when drawn to the rear it presses the sides of the cheeks against the sides of the platform: to remove the compression for running up the lever is drawn to the front. This compressor is rarely used and may be considered obsolete.

PIVOTS AND RACERS FOR TRAVERSING PLATFORMS.

Pivots.—The pivot of a wood casemate platform is always an imaginary one just under the muzzle of the gun when run up, and termed "A" pivot: for dwarf platforms the pivots are A, C, D, E, or F; C being at the centre and the others in rear. A is an imaginary pivot, the others either actual or imaginary as required.

The pivots of wrought-iron traversing platforms are A, C, and D; A pivot being imaginary and used always with casemate platforms.

Racers.—The racers for wood platforms are of wrought iron, and raised above the ground, the upper surfaces being rounded off.

Racers for iron platforms are now made of steel.

TRANSPORTING ARRANGEMENTS FOR SLIDING CARRIAGES AND TRAVERSING PLATFORMS.

In wood sliding carriages, an axle-tree on which is a pair of wheels is passed through a hole in the front block, and the rear of the carriage is limbered up to a dilly: the pintail of the latter passes through an eye plate in the rear block of the carriage. The platform can be transported by the same arrangement, the axle-tree passing through bands for the purpose.

Wrought-iron sliding carriages are not fitted for the transporting axle and dilly, but can be transported when necessary on their platforms.

When there are no fittings on wrought-iron platforms for the axle and dilly, the latter can be used by lashing the axle under the platform, and supporting the latter on the dilly by means of skids lashed to the platform, which is then secured by a chain to the dilly.

CHAPTER X.

TRANSPORTING CARRIAGES AND MACHINES.

TRANSPORTING CARRIAGES.

Drugs.—A drug consists of a platform of oak over a fore and hind carriage with low trucks. It is used for transporting guns up to 25 tons on good hard roads.

Sleighs.—A sleigh consists of two side pieces of oak connected by transoms: it is used in conjunction with rollers for trans-

porting guns up to 38 tons: a sleigh of lighter construction is made for guns up to 25 tons. Temporary sleighs are frequently used for moving guns up to 12 tons.

Platform Wagon.—The wagon consists of a fore and hind carriage with a platform fitted over them with 5-foot wheels. It is constructed to transport weights either ordnance or stores up to 3½ tons. A gun is mounted on the wagon by means of a gyn, by parbuckling up the side or front, or by shifting it from its carriage on to the wagon by rollers. When in position for travelling, the muzzle of the gun is towards the front of the wagon.

Sling Wagon.—The wagon is made of wood or iron. In the former case it is of oak, and consists of a body and limber. The frame of the body is formed of a perch, two sides, two cross-bars, two brackets, and an axle-tree bed. The brackets are short and low, and are bolted one on each side over the axle-tree bed for the support of the windlass. The windlass, of elm, is cylindrical in the centre with octagonal ends; there is a ratchet arrangement at either end. At the centre of the windlass is placed a hook, to take an eye which is formed in the centre of the special gun sling that is used; and upon the axle-tree bed in front and rear on each side there is a similar hook or pin to take an eye splice that is formed at each end of the sling. The sling passes round the trunnions of the gun on which iron thimbles are placed, the muzzle of the gun being towards the rear of the wagon: the gun is then raised by working the levers placed in the sockets, and the breech is lashed up to the perch. A detachment of 9 numbers is required, and the stores issued with the wagon are a 5-inch sling of white rope, two iron thimbles, a lashing of 2½-inch tarred rope, two levers, and two pawls: the latter are placed in the mortise holes in the windlass to prevent it from turning round when limbering up, which is done by bearing down on the levers, and lifting the perch. The wagon must be limbered up before the gun is raised.

Mark I. sling wagon (wood) has cast-iron fittings, and is constructed for weights up to 4¾ tons.

Mark II. has wrought-iron fittings, and can be used for weights not exceeding 6 tons. For the iron sling wagon 7 tons is the maximum weight. The body of the wagon has 7-foot wheels, those of the limber being 5-foot. The wheel track of the wooden wagon is 6 feet 6 inches, that of the iron one being 5 feet 11 inches. A few sling wagons have been constructed to take 12 and also 23-ton guns, but they are retained for use in arsenals.

A 12-ton gun can be transported by two sling wagons, the gun being slung at the cascable and half-weight mark.

Sling Cart.—This cart has two long sides which form the

shafts; upon these brackets are bolted; a similar windlass to that of the sling wagon is used. The breech of the gun is lashed up to a prypole in rear of the cart. A detachment of 7 numbers is required, and the maximum weight the sling cart will transport is 3¼ tons: the earlier patterns having cast-iron fittings, will take weights not exceeding 56 cwt. The wheels are 5½ feet in diameter, and have a wheel track of 5 feet 9 inches.

Trench Cart.—This cart is used for weights not exceeding one ton: it is painted red.

The Hand-cart is lighter but otherwise similar to the trench cart: it is constructed to take weights not exceeding 15 cwt., and is painted a lead colour.

Machines.

Triangle Gyns.—The following natures are in the Service, viz.:

1. 16 ft. wood to raise 70 cwt., weight of gyn 9 cwt.					
2. 18 ft. light wood (II.) to raise	7 tons,	weight of gyn	14¼ cwt.		
3. 18 ft. heavy wood	„	12	„	„	26½ „
4. 18 ft. light iron	„	7	„	„	16 „
5. 18 ft. heavy iron	„	12	„	„	28 „

Those of wood are no longer made: and the earlier patterns of those which exist having cast-iron fittings will only take 6 tons in the case of the 18-foot light gyn, and 60 cwt. in the 16-foot gyn.

The maximum weights gyns will take are: in the case of the 16-foot gyn when the foot of the prypole is 12 feet distant from a perpendicular let fall from the centre of the windlass: for the 18-foot light gyn the perpendicular distance is 13 feet, and 15 feet for the 18-foot heavy gyn.

A gyn consists of two cheeks with cross-bars, a prypole, a windlass, and a shackle with bolt and key: the cheeks are connected by the iron cross-bars, the windlass being first placed in position with its gudgeons in the gudgeon holes of the cheeks.

The cheeks and prypole are of fir in the case of wooden gyns and of iron tubing in the iron ones; the shackle and head-bolt are of wrought iron; the upper block of the tackle is hooked to the shackle point towards the prypole.

In the latest patterns of iron gyns the shackle is dispensed with, and the block is hooked on to the head-bolt; a space for the hook being made by forking the head of the prypole. Pawls for the windlass are attached to the inside of each cheek.

The tackle used with the 16-foot gyn consists of a treble and double 10-inch block rove with a 3½-inch fall. With the 18-foot

light gyn, two treble 12-inch blocks rove with a 4-inch fall: with the 18-foot heavy, two treble 15-inch blocks and a 5-inch fall.

Levers of wood are used to work the windlass of gyns and so raise the weight; the running end of the fall of the tackle being passed three, four, or five times round the windlass and held on to.

Wooden trucks are provided for the feet to prevent them sinking, the trucks having holes to receive the spikes in the feet.

In taking weights with gyns, the cheeks and prypole should be lashed together at the feet and the cheeks be equidistant from the prypole, and all on the same level: the more upright a gyn is, the greater weight will it bear.

The prypole is the front of the gyn, and the gyn should be placed with its head over the centre of gravity of the gun or weight to be raised: the weight should never be hauled to the right or left when suspended; slightly hauling it to the front or rear is allowable.

In raising or striking heavy gyns, two drag-ropes joined together should always be made fast to the prypole and passed round the windlass and held on to.

In lowering heavy weights, the levers must always be used: for light weights the fall may be eased off round the windlass.*

Two gyns can be used to raise a weight arranged so as to take equal weights or proportionate weights if of different natures: the cheeks of either being on opposite sides of the weight.

A detachment of 13 Nos. is required for working the 16-foot or 18-foot light gyns, and of 19 Nos. for the 18-foot heavy gyn.

Gyns may be struck and then lifted by the detachment shoulder high, and so carried considerable distances: it is only advisable to carry them in an upright position a short distance.

To calculate theoretically the power gained by a gyn: it may be considered as a lever of the second order; the power P acting at a certain point in the gyn lever, the weight being on the fall at the inner edge of the barrel of the windlass. Taking the effective leverage as 7 feet 5 inches, or 89 inches, and the counter lever as half the diameter of the barrel of the windlass and of the fall,

$$P : W :: 4\tfrac{1}{2} \text{ inches} : 89 \text{ inches} :: 1 : 19\cdot77.$$

The power due to tackle is 6 to 1. So that theoretically the total power gained is 118·6 to 1.

The Gibraltar Gyn is used for mounting and dismounting ordnance on standing carriages in casemates or other places where there is no overhead room for a triangle gyn: it will take weights up to

* Maximum weights that can be eased off round the windlass:

18-foot light gyn	.. .. ..	3 tons.
18-foot heavy gyn	.. .. ..	5 „

PL. XVI

HYDRAULIC LIFTING JACK.

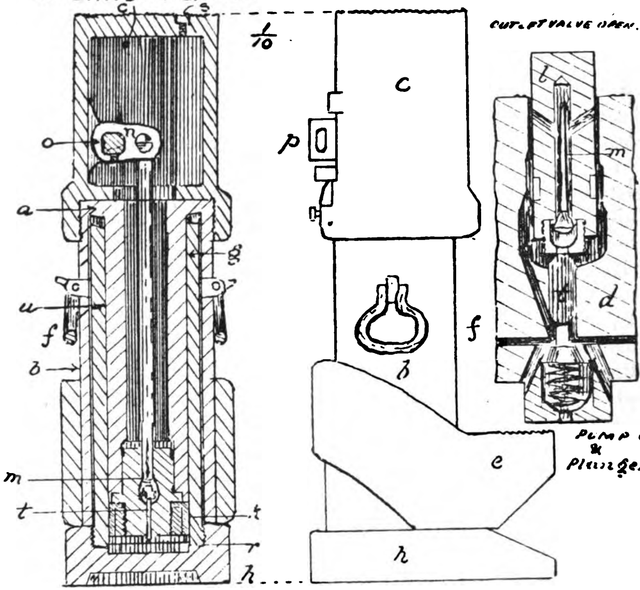


FIG. 1.

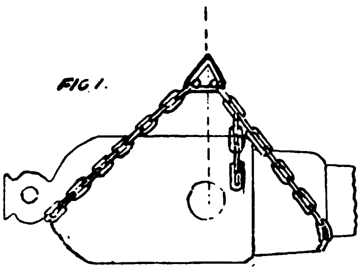
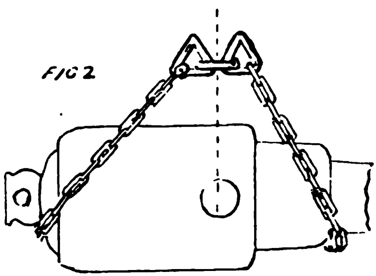


FIG. 2.



CHAIN SLING ARRANGED FOR 12 TON AND 18 TON GUN.

[To face p. 87.

3 tons: it is now but little used. It consists of two uprights connected at their upper ends by a cross beam, and is fitted with a windlass in rear of one of the uprights, and also with four trucks for moving it. There are three sheaves in the cross beam through which and the lower block the fall is rove, passing round the windlass which is worked by handles: the direction of the cross beam is at right angles to the axis of the gun when raising it. The detachment consists of 7 Nos. The power gained theoretically is 115 to 1.

The Crab Capstan is used for the purpose of applying power at the running end of the fall when moving or raising weights. It consists of a framework of wood and iron, in which a barrel is supported in a vertical position. The fall is passed round the barrel which is made to revolve by two capstan bars passed through mortises in the head. When used it is secured to a holdfast. 12 Nos. walk round on the ends of the bars and 2 Nos. are required to hold on the fall. The power gained is 13 to 1. Two tons on the barrel is the maximum strain that may be exerted.

The *Iron Crab* or *Winch* consists of a barrel supported horizontally in a cast-iron frame bolted to a wooden one: it is provided with a brake and two winch handles, and can be used on the "slow" or "quick" purchase. The winches in the Service are constructed to exert a strain of 2 and 5 tons on the slow purchase, and half those weights on the quick purchase.

Lifting Jacks.—Of these there are four kinds for garrison service. 1. Clerk's screw; 2. The rack and pinion; 3. Haley's screw; 4. Hydraulic.

Clerk's screw jack will lift 5 tons.

The rack-and-pinion jack 3 tons.

Haley's screw jack from 2 to 20 tons.

Hydraulic Jacks.—These jacks are constructed to lift weights of from 7½ to 30 tons. They are alike in general form and internal arrangement (Plate XVI.). The ram (*a*) with external casing, both of steel, is secured to the reservoir which is of malleable cast iron. To the external casing are attached a wrought-iron claw (*e*) and the lifting handles (*ff*). At the bottom of the ram are the gun-metal pump (*d*) and the leather packing (*k*). The plunger (*l*) is of steel, and contains the inlet valve (*m*). It is connected to a crank (*n*) on a spindle (*o*) supported in bearings on the sides of the reservoir (*c*). The spindle (*o*) of steel has a socket (*p*) outside the reservoir for the lever; the ram cylinder (*g*) of steel fits over the ram (*a*) and slides between it and the external casing (*b*). It is screwed into a malleable iron foot, and is fitted with a leather packing (*r*). At the top of the reservoir is an air hole with a wrought-iron screw

plug (*s*) and leather washer. By it the jack can be filled or emptied; the lever handle has a screwdriver formed on one end of it, for removing the plug.

Action.—The lever acting upon the crank (*n*) raises and lowers the plunger (*l*). By the up stroke a vacuum is created in the pump, and the pressure of the air in the reservoir forces the fluid past the inlet valve (*m*) in the plunger; at the down stroke the inlet valve (*m*) closes, and the outlet (*t*) opening, the fluid is forced from the pump under the ram, thus raising it with the load. A small hole (*u*) limits the height of lift by allowing the fluid to escape when the ram leather passes it. To lower: the lever is shifted in the socket (*p*) so as to bring its shoulder upwards, and then pressed gently downwards until the plunger touches the valve (*t*). It is then forced down to its full extent, which opens the outlet valve (*t*) and allows the fluid in the cylinder to escape through the space round the plunger (*l*) in this position back to the reservoir. The jacks are filled with methylated spirits.

In the older patterns of jacks the internal arrangement is different: and in lowering off, the handle is partially drawn off the spindle, till it can pass the stop and is then forced down. In still older patterns a screw at the side of the reservoir is eased off when the cylinder descends.

In raising weights, jacks should stand upright on a hard smooth surface, oak and not fir skids should be used as a base. A thin piece of wood or a little hemp should be placed between the weight and the head or claw of the jack: long strokes of the handle are the best, and the weight as it rises should be followed up closely. Great care is required in using jacks, and also to keep them in proper working order.

CHAPTER XI.

TACKLES, CORDAGE, SKIDDING, ETC.

BLOCKS.

BLOCKS are single, double, or treble, according to the number of their sheaves, and are of two kinds—Admiralty and Bothway's.

An Admiralty Block consists of a shell of elm and sheaf or sheaves of wood or metal revolving on an iron pin supported in the shell: the block is strapped with rope, which attaches the hook at one end to the shell and the thimble or loop at the other. The shell itself bears the strain, consequently this kind of block is

of weak though light construction, and is principally used for tackles in running back at drill.

A Bothway's Block consists of a shell of elm, one or more metal sheaves with iron pin, two or more wrought-iron straps according to the number of sheaves, a shackle with swivel hook and pin.

The smaller natures of blocks have a small shackle with thimble and pin for the attachment of the standing end of the fall: in the larger natures the latter is made fast to a button formed on the head of the pin that supports the sheaves; the sheaves are of phosphor bronze, which is bronze hardened by an admixture of phosphorus, and are stamped with the letters P.B. In a Bothway's block, the sheave pin passes through the straps which take the strain; the shell merely serving to keep the fall in its proper position.

All blocks are measured by the length of their shell in inches, and they will take a rope whose circumference is one-third of their length.

The sizes of Bothway's blocks are from 8 to 21 inches; those of Admiralty blocks 3 to 9 inches.

A Snatch Block is an iron-bound single Admiralty block: on one side the strap opens with a hinge, so that a rope can be passed on to the sheaf at once: it is used for changing the direction of the running end, or end hauled on of a tackle. They are in sizes from 8 to 21 inches.

All blocks should be kept clean and lubricated, in order to reduce friction as much as possible.

Rope.

A rope is formed of three strands; each strand being made up of a number of yarns, and each yarn of a number of fibres of hemp. It is either white or tarred, and its size depends on the number of yarns. The size of rope is the measurement of its circumference in inches. New rope is usually issued in coils containing 113 fathoms. In size it ranges from $1\frac{1}{2}$ to 12 inches.

In order to find the strain that can be put on any rope, divide the square of the circumference in inches by 7 for new and by 8 for part worn rope; the quotient is the strain it will bear in tons: thus for $2\frac{1}{2}$-inch old rope:

$$\frac{5}{2} \times \frac{5}{2} \times \frac{20}{8} = 15 \cdot 6 \text{ cwt.}$$

To find the weight of rope, multiply the square of the circumference in inches by the length in fathoms and divide by

480 for the weight in cwts.: thus for a coil of 113 fathoms of 3-inch rope,

$$\frac{3 \times 3 \times 113}{480} = 2 \cdot 1 \text{ cwt. (weight).}$$

A stranded rope is unreliable, and may be known by one strand projecting beyond the others owing to its having been unduly strained.

Rope Slings are used for slinging ordnance or other weights to be raised. A sling is made of white rope and is measured on the double; the circumference of the rope of the sling and the calibre of the piece to be raised should correspond, as a guide for the size of the sling required. The nearer the point of suspension is to the upper surface of the gun or other weight, the greater will be the strain on the sling: slings should never be twisted up in order to shorten them.

They are made in sizes as follows:—

6-inch, 12 feet 6 inches long, for raising 5-ton guns and under (one tackle).

7-inch, 14 feet 6 inches long, for raising 7-ton guns and under (one tackle).

9-inch, 3 feet long, fitted with thimbles for use at cascable when raising 12 to 25-ton guns with two tackles.

9-inch, 7 feet long, fitted with thimbles for use at half-weight mark when raising 12 to 25-ton guns with two tackles.

9-inch, 16 feet long, for raising 12-ton guns with one tackle, and slinging 35 and 38-ton guns at half-weight mark.

12-inch, 4 feet 4 inches long, for use at cascable, trunnions or half-weight mark in lifting 35 or 38-ton guns.

Iron and steel wire rope is used occasionally for the guys of sheers.

CHAIN.

Chain is used in place of rope when working with very heavy weights. It is measured by the diameter of the iron forming the link.

In order to find the safe working load, square the diameter of the iron in eighths of inches and cut off the last figure as a decimal for the strain in tons; thus in the case of 1-inch chain,

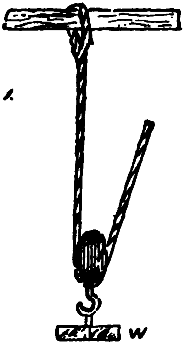
$$8^2 = 64; \; 6 \cdot 4 \text{ tons is the working strain.}$$

Chain Slings.—A 1-inch link chain sling 12 fathoms long is used for raising 12-ton guns with one tackle.

Also for the same purpose and for raising 18 and 25-ton guns with two tackles, breech and muzzle chain slings with triangular links are used. The breech and muzzle slings are connected by two triangular links and three shackles; they can be so arranged

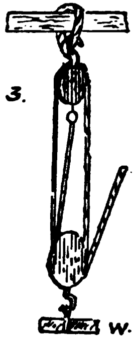
PL XVII.

1.



2

3.



4 TO 1.

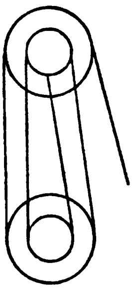
WHIP. 2 TO 1.

WHIP UPON WHIP. 4 TO. 1.

LUFF TACKLE. 3 OR 4 TO. 1.

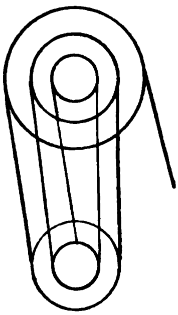
4

4 OR 5 TO 1.



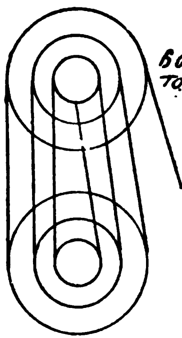
5

5 OR 6 TO 1.



6.

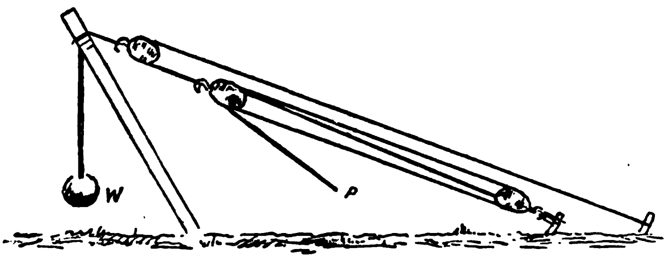
6 OR 7 TO 1.



GUN TACKLE.

HEAVY GUN OR LIGHT GYN.

GYN TACKLE.



RUNNER TACKLE. 8 TO 1.

[To face p. 91.

according to the nature of gun that the breech sling is over the cascable, the muzzle sling over the chase, and the triangular link or links over the centre of gravity of the gun. (Plate XVI. Figs. 1 and 2.)

TACKLES.

A tackle consists of one or more blocks rove with a fall of rope. The end of the fall that is made fast is called the standing end; the other end, being that to which power is applied, is termed the running end.

The tackles used in the Service are: (Plate XVII.)

1. One fixed block giving no mechanical advantage.
2. A *whip:* one single movable block; gain of power, 2 to 1.
3. A *whip upon whip:* two movable blocks; gain of power, 4 to 1.
4. *Luff tackle:* a double and single 8-inch block, $2\frac{1}{2}$-inch fall; gain of power, 3 or 4 to 1 as used. (Fig. 3.)
5. A "*gun tackle,*" two double 8-inch Admiralty blocks rove with a $2\frac{1}{2}$-inch fall; gain of power, 4 or 5 to 1. (Fig. 4.)
6. A *heavy gun tackle:* one double and one treble 9-inch Admiralty blocks, 3-inch fall; 5 or 6 to 1 as used. (Fig. 5.)
7. *Light gyn tackle:* the same, but 10-inch Bothway's blocks are used, and a $3\frac{1}{2}$-inch fall for 16-feet gyn. (Fig. 5.)
8. *Gyn tackle:* two treble 12-inch or 15-inch blocks with a 4-inch or 5-inch fall; power gained, 6 or 7 to 1 as used. (Fig. 6.)*
9. A *runner tackle* is one that is applied to the running end of the fall of another. (Fig. 7.)

To calculate the power gained by any tackle, take the sum of all the returns that act directly on the movable block, and in a combination of tackles multiply together the power gained by each to find the power gained by all. In consequence of friction and the rigidity of a rope, it is the rule to add $\frac{1}{8}$th of the weight for every sheaf in use.

Example I.—Find the greatest strain that a luff tackle will take, a part worn fall being used, and the double block being the movable one; gain of power, 4 to 1. The total resistance $R = W + \frac{3}{8}W = \frac{11}{8}W$, there being three sheaves in use, and $\frac{R}{4} = P = 15\cdot 6$ cwt., the maximum strain a $2\frac{1}{2}$-inch rope will take;

$$\therefore\ 15\cdot 6 = \frac{\frac{11}{8}W}{4} \text{ and } W = 45\cdot 38 \text{ cwt.}$$

* 18-foot light gyn takes 12-inch blocks.
18-foot heavy gyn „ 15 „

Example II.—Find what power must be applied at the running end of the fall of a gyn tackle consisting of two treble 12-inch blocks to raise a weight of 12 tons; power gained, 6 to 1.

Since there are six sheaves, the total resistance is

$$R = W + \frac{6}{8} W = \frac{14}{8} W = \frac{14}{8} \text{ of } 12 = 21,$$

and

$$\frac{R}{6} = P \text{ (power)};$$

$$\therefore \quad P = \frac{21}{6} = 3\tfrac{1}{2} \text{ tons.}$$

Levers and Handspikes.

Handspikes are made of ash, and are either 6 or 7 feet in length (latter for guns above 80 cwt.); the lower end is square, ending in a bevel termed the point; the upper portion of the handspike is oval in section, terminating in the small end.

Levers are similar in shape, but their points are not bevelled except in the 12 and 14-foot levers; 8, 10, 12, and 14-foot levers are those in use.

In using levers or handspikes they are applied as levers of first or second order.

First order is when the fulcrum is between the power and weight, as in elevating the breech of a gun, using the side of the carriage as a fulcrum.

Second order is when the weight is between the power and the fulcrum, as in running up a standing carriage, the ground being the fulcrum and the axle of the truck the weight.

The length between the point of application of the power and the fulcrum is the lever (L), that between the weight and the fulcrum the counter lever (C L); and in both cases the power multiplied by the lever is equivalent to the weight multiplied by the counter lever, or P × L = W × C L. Example: a 10-foot lever is applied to raise a weight of 16 cwt., as a lever of first order, with a counter lever of 1 foot; the point of application of power being 1 foot from the small end, to find the power required we have

$$\left.\begin{aligned} L &= 8 \text{ feet} \\ C\,L &= 1 \text{ foot} \\ W &= 16 \text{ cwt.} \end{aligned}\right\} \begin{aligned} &\text{and } P \times 8 = 16 \times 1. \\ &\quad \therefore \quad P = 2 \text{ cwt.} \end{aligned}$$

Iron-pointed Levers are of ash with wrought-iron points, and are

used in running up wrought-iron sliding carriages; they are inserted in the sockets, and the small ends being borne down the rear rollers of the carriage are brought into play.

Iron-shod Levers are short levers shod with iron and used for traversing platforms, but not fitted with traversing gear; they are applied under the front or rear trucks according to the nature of pivot.

Truck levers are used for running up wood sliding carriages on traversing platforms; they are 7 feet long and have at the point a plate of iron with hook and pawl and metal trucks.

Skids.

Skidding for mounting and dismounting ordnance and other uses in artillery service is made of fir or oak, and in the following sizes, viz.:

Material.	Length.	Section.
	feet.	inches.
Fir	20	15 × 15
,,	20	9 × 9
,,	14	8 × 8
,,	6	12 × 12
,,	4	12 × 12
Oak	14	5½ × 5½
,,	5	6 × 5
,,	3	6 × 9
,,	3	6 × 3
,,	3	6 × 6
,,	3	4 × 4
,,	3	3 × 3
Oak beam	11½	10 × 20
,,	10	9 × 15
,,	10	8 × 13

English oak is used and either Memel, Dantzic, or Riga pine. The weights of 1 cubic foot of each are:

English oak	48 lbs.
Memel pine	34 ,,
Dantzic pine	40 ,,
Riga pine	41 ,,

The weight of any skid, beam or spar, can thus be easily calculated.

In order to find the weight that any beam or skid can bear

when supported at two points and loaded at an intermediate point between them, it is necessary to remember the following formula

$$W = \frac{4\,b\,d^2\,S}{l},$$

where W is the breaking weight in pounds.

b „ breadth or horizontal measurement.

d „ depth or vertical measurement of a section of the beam in use, all in inches.

l „ distance between points of support in inches.

S is a coefficient whose value is for fir 1100, for oak 1977.

For selected timber, $\frac{1}{2}$ W is safe working load.

For unselected timber, $\frac{1}{4}$ W is safe working load.

Planks are used underneath skidding on soft ground, as a roadway for a sleigh, or a gun on rollers; and on the top of long skids, when parbuckling heavy guns; in this latter case, oak planks should be made use of.

TABLE OF SERVICE PLANKS.

Material.	Length.	Width.	Thickness.	
	feet.	inches.	inches.	
Fir	12	9	3	Whole.
„	10	17	3	„
„	5	17	3	Half.
Oak	10	17	3	Whole.
„	6	12	3	Half.
„	4	12	3	„

Rollers are used for mounting, moving, and shifting ordnance. There are the following kinds in the Service:

Material.	Length.	Diameter.	Use.
	feet.	inches.	
Elm	6 and 4	10	Ground rollers.
„	6 and 3	6	„
„	3 and $2\frac{1}{2}$	5	„
Sabicu	14 in., 20 in., 2 ft., $2\frac{1}{2}$ ft., and 3 ft.	5	Shifting rollers.
Oak	7 and 8	12	For heavy sleighs.

A weight moving on rollers travels twice as fast as the rollers, friction is reduced, but no mechanical advantage is gained.

There are other special gun rollers used for shifting guns

mounted on travelling siege, and overbank carriages; a roller being made to suit each particular carriage.

Scotches are made of elm, in three sizes, large, medium, and small; they act as wedges and are placed in front or rear of any weight to prevent its moving.

Picket Posts are made of ash shod with an iron point and hooped at the head. They are 5 feet, 6 feet, and 8 feet long for garrison service, 2½ feet long for field service.

Holdfasts are required when heavy weights are being moved or suspended: in good holding ground, picket posts driven into the ground answer the purpose: an ordinary arrangement is to drive three, two, and one pickets into the ground and lash them; they will stand a strain of about 2 tons. For heavier weights, pickets in conjunction with a baulk of wood or a heavy gun or beam sunk in the ground may be used, as circumstances and the nature of the ground require.

CHAPTER XII.

SHEERS, DERRICKS, AND NOTES ON MOUNTING AND DISMOUNTING ORDNANCE.

SHEERS.

SPARS for sheers are made of fir, and vary from 30 to 70 feet in length, and 11 to 24 inches in diameter, according to the weights they may be required to raise. 40-foot spars, 12 inches in diameter, would be suitable for raising weights up to 5 tons; whilst for 38 or 43-ton guns, 70-foot spars would be used; the stores, cordage, blocks, &c., being proportioned to the size of the spars used.

Light Sheers.—To rig and raise a pair of sheers to lift 5 tons, 40-foot spars being used; the following is briefly the operation.

Sections consisting of about 4 to 6 numbers each, would be told off for the duties, viz.: 1. Head of sheers; 2. Feet of sheers; 3. Fore guy; 4. Back guy; 5. Main tackle, sling for weight, leading block with lashing, stopper, steadying ropes; 6. Crab capstan.

The undermentioned stores would be required.

Rope.—Head lashing, 25 fathoms of 3-inch white rope.

Fore guy, 56 fathoms of 4½-inch tarred rope.

Runner for fore guy, 56 fathoms of 2½-inch tarred rope.

Back guy the same as for fore guy.

Main tackle, one coil of 4-inch white rope.

Blocks, Bothway's.—Two 12-inch single, for fore and back guys.

Two double and two single 8-inch blocks for runners.

Two 12-inch treble blocks, and one 12-inch snatch block for main tackle.

Rope Slings.—One 6-inch sling for main tackle.

Two 5-inch straps for fore and back guy.

One 6-inch sling for slinging the weight.

One crab capstan complete for taking in the main fall.

Three sets of luff tackle and shoes for feet of spars, and in addition light lashings, handspikes, picket posts, mauls, selvagees, intrenching tools, spun yarn.

Splay.—The splay of the spars should be one-third of their length, measured to the crutch. The distance of the holdfasts should be twice the length of the spars to the crutch, measured from the foot of the spars.

Holdfasts.—For the guys and capstan holdfasts, three, two, and one pickets (5-foot) would be suitable, and for the feet of the spars two and one pickets placed 5 feet from the feet and slightly outwards. The shoes to be embedded in the ground.

Head Lashing.—The lashing is made fast to the lower spar above the crutch with a timber hitch, and a sufficient number of returns are taken round both spars towards the feet; the end is then led round this lashing and both spars from front to rear or from rear to front, which tends to keep the spars together, and made fast on the upper spar with a clove hitch. The straps into which the single blocks of the guys are hooked are each placed with one turn round the spar farthest from the guy and then round both spars to help to keep them from separating. The sling for the main tackle is put on single or double; if single, it is passed up one spar and between both at the top; if on the double, it is passed over the top between the spars.

Guys.—A 12-inch single block is hooked to each guy strap, the guy rope is passed through the block, and a hawser bend made into which the runner tackle is hooked. The guy should be three times the length of the spars from the hawser bend to the front or rear holdfast. The standing end of the guy is made fast to the holdfast, the remainder being coiled down. By the guy the power gained is 2 to 1, and 4 to 1 by the runner tackles consisting of a luff tackle, or in all 8 to 1.

The *Crab Capstan* should be placed nearly in line with the feet of the sheers, and the leading block through which the fall of the main tackle passes to the capstan is lashed to the farthest spar.

Foot Tackles.—One luff tackle between the feet of the spars to

prevent them splaying outwards, and a luff tackle to each foot which is eased off as the feet come into the shoes.

Raising the Sheers.—Sheers of this nature would be probably raised by the back guy by means of a 14-foot lever, the small end of which is made fast to the back guy between the hawser bend and the block at head of sheers; a 2½-inch rope is clove-hitched over the small end of the lever forming side guys for it, which are kept outside of the back guy, and are made fast each to a single picket, being let go altogether as the lever comes vertical when the sheers are rising. The butt of the lever is towards the feet of the sheers and rests against a skid held by pickets.

To prevent any blocks twisting and so causing an amount of friction, handspikes are lashed to them.

The numbers man the fall of the runner tackle of the back guy and so raise the lever and afterwards the sheers until nearly vertical.

Moving to the front.—The sheers having been raised with the back guy would have to be moved to the front to the edge of the pier or other position, which is done as follows: a spar is lashed across the sheer spars close to the ground, and planks placed lengthways under each foot: tackles are used to haul the feet forwards, assisting with handspikes applied under the cross spar; the back guy being eased off and the fore guy taken in at the same time, the head of the sheers being slightly inclined inwards.

Taking the Weight.—To raise the weight the fall of the main tackle is taken in by the crab capstan. Seven or eight degrees of heel should be allowed for, owing to the stretch of the back guy when the weight is taken. As a rule the heel of the sheers from the vertical should not exceed 20 degrees, which gives a strain on the back guy of half the weight of the sheers and the weight, &c. (Plate XVIII. Fig. 3).

Raising by Gyn.—Light sheers may be also raised by using the cheeks of a gyn as a crutch for the back guy, the standing end of which rests on the head bolt of the gyn, and the running end is manned.

Raising by Derrick.—Another method is to raise the sheers by means of a derrick or single spar about 25 feet long for 40-foot sheers. The derrick is placed with its head midway between the feet, its butt towards the head of the sheers. A leading block is made fast to the head and foot of the derrick, and it is provided with side guys and a back guy. The lower block of the main tackle is made fast to one of the sheer spars, and the running end is passed from the upper block of the main tackle to the leading block at the head of the derrick, and through the leading block at its foot to the capstan. The numbers walk round on the capstan

and so raise the derrick: when nearly perpendicular its back guy is made fast, and by continuing to walk round on the capstan the sheers will rise till high enough to be under the control of the back guy, by which the remainder of the raising is completed: the derrick is then lowered by walking back on the capstan (Plate XVIII. Fig. 2).

Heavy Sheers.—In the case of 60 or 70-foot spars, two main tackles would be employed, and the sheers would be raised by a derrick 40 feet in length, the latter being raised by the cheeks of a gyn. 18-inch or 21-inch blocks and 6 or 7-inch falls would be required for the main tackles. As a rule the sheers would be fitted with a head bolt and furnished with wire guys and short chains for suspending the upper blocks of the main tackles. If not so fitted the head lashing would consist of 4-inch white rope. One or two guys of 6-inch rope rove through a single and double 18-inch Bothway's block would be used: power gained by each guy, 4 to 1. The running end of each guy would lead straight away from the double or movable block to the barrel of the 5-ton crab by which the guys would be worked.

Strain on back Guy.—To find the strain on the back guy of sheers and the thrust on spars (Plate XVIII. Fig. 1).

First method, tension of guy $\times$ F P = W $\times$ F E + weight of spars $\times$ F D.

Second method by construction.

If A B = W + weight of main fall + $\frac{1}{2}$ weight of spars, then A G represents strain on back guy, A H represents thrust on spars; B H being drawn parallel to A P and H G parallel to A B.

Lever Sheers would only be used for weights not exceeding 5 tons, and when a back guy only can be fixed. A crutch of the desired height is prepared in the ordinary way. A long spar is laid on this, having the upper block of the main tackle made fast to the projecting end: the foot of the long spar is firmly butted in the ground to prevent it slipping back, and is kept from rising by being weighted or lashed to pickets driven in across it (Fig. 4).

Gyn Sheers.—The prypole is lengthened by lashing another spar to it about 20 feet in length, forming a strut in place of a fore guy. To the end of the lengthened prypole the movable blocks of two tackles are fixed, the standing to the feet of the cheeks: by these side tackles the gyn sheers are raised and the amount of heel regulated. The weight raised must be under that for which the gyn is intended.

Derricks are used for lighter weights than sheers, and also to raise sheers themselves. When the weight is taken it can be slewed through a considerable space and then lowered. A derrick may be either "standing" or "swinging." The former is used

PL. XVIII.

FIG. 1.

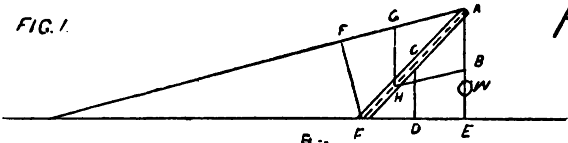
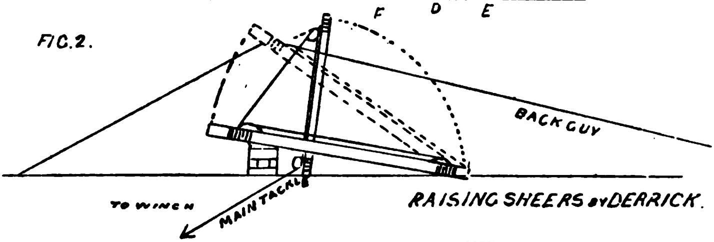
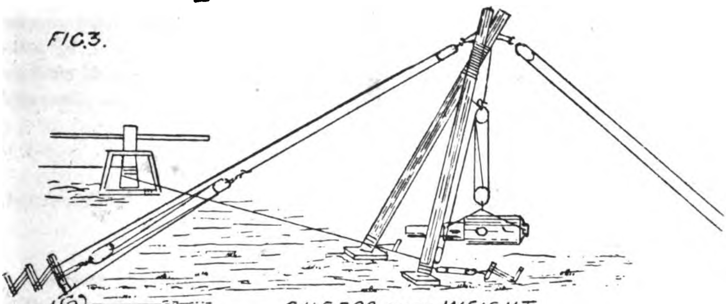


FIG. 2.



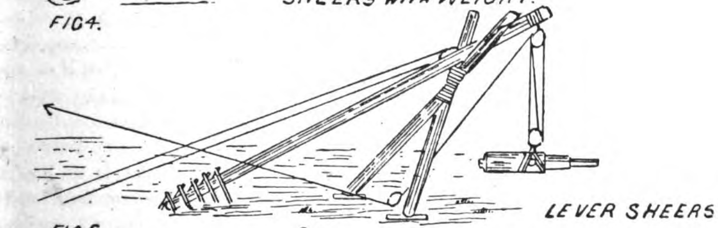
RAISING SHEERS BY DERRICK.

FIG. 3.



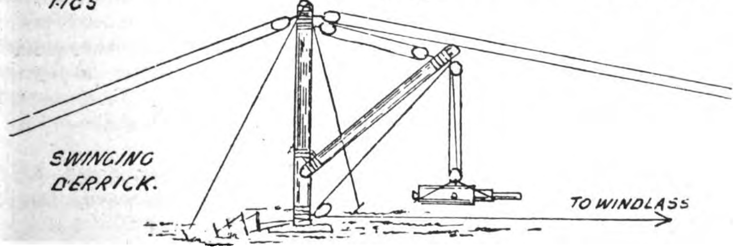
SHEERS WITH WEIGHT.

FIG. 4.



LEVER SHEERS.

FIG. 5



SWINGING DERRICK.

when a direct lift or slight lateral play is required: the latter when the weight to be raised is lighter and more lateral play is required. In addition to the stores for ordinary sheers, two side guys will be required: the derrick is raised by the same means as sheers.

Swinging Derrick.—A swinging spar is prepared with a main tackle and connected to the upright by the main tackle of the standing derrick; its butt is lashed to the upright or supported in a shoe at the foot of the derrick (Fig. 5).

NOTES ON MOUNTING, DISMOUNTING, AND MOVING ORDNANCE, CARRIAGES, &c.

Mounting and dismounting guns of 5 tons and under.—Guns on garrison standing carriages may be mounted and dismounted by

1. Gyn, or Gibraltar gyn if in a casemate.
2. Parbuckling up and down the side by 14-foot skids.
3. Up and down the rear either with or without rollers and may be shifted from carriage to carriage by plank and rollers, and by slewing.

Guns up to 5 tons mounted on traversing platforms would be mounted and dismounted by the gyn or by watered skids up and down the rear, or if in a casemate provided with overhead bolts, by means of tackles.

Mounting and dismounting 7-ton guns and upwards.—A 7-ton gun can be mounted or dismounted by the light 18-foot gyn alone, or by watered skids up and down the rear.

A 12-ton gun by the 18-foot heavy gyn alone, using the chain sling, or dismounted by watered skids down the rear, but should not be mounted by the latter method.

The following methods are applicable to 7-ton guns and upwards in an open battery.

1. One gyn (guns up to 12 tons).
2. Two gyns, provided the weight on either gyn is not exceeded: the cheeks of the gyns are placed on opposite sides.
3. One gyn at the cascable, and building up with skidding under the muzzle in the port if the carriage and platform are to be removed: or building up on the platform if the carriage only is to be taken away.
5. Gyn at the cascable and jack or levers at the muzzle. The gun is run up till the muzzle is just inside the shield or work, and cross-built skidding is arranged under the short coil. When the gun is high enough the carriage is run back and dismounted if necessary. The gun is then lowered breech and muzzle alternately by the gyn at the breech and jack or levers at the muzzle

on to skidding across the platform, from which it is parbuckled on to a sleigh or as required: the carriage and platform being run to the rear on a temporary sleigh.

5. Jacks alone, should no gyn be available. In this case the gun is supported under the short coil by a long skid supported at either end so as to leave about 7 feet in the clear. An oak beam is lashed to the cascable and a jack placed under either end of it, leaving as before 7 feet clear between the supporting piles of skidding. By this means the carriage and platform can be removed to the rear. It is preferable and requires less skidding to support the muzzle end of the gun on the platform, and to parbuckle the gun on or off the platform, removing the carriage and platform separately. Screw jacks are preferable to hydraulic jacks for the final operation in either case, as they admit of the weight being traversed, and it is easier to keep the beam horizontal.

In casemated works heavy guns would be mounted and dismounted as follows:

1. In casemates fitted with overhead bolts of sufficient height by Yeatman's tackles for guns up to 25 tons. In this case strong iron shackles replace the swivel hooks and shackles of Service blocks: for the breech 18-inch treble blocks are used, suitable in the case of the lower block for attachment to the cascable, and in the upper block to a loop fixed in the arch of the casemate. A 3-inch short wire rope with eyes is used under the muzzle, and two muzzle tackles are employed, consisting each of two treble 12-inch blocks having shackles in place of hooks; the object of the special blocks in both cases being to obtain increased lift. The falls of all three tackles are led away to iron crabs either through leading blocks or direct as required.

2. By overhead tackles at breech and jack at the muzzle. This operation is similar to that in which the gyn is used at breech and jack at the muzzle, with the exception that in place of the gyn the breech tackle is worked by an iron crab; the lower block may be secured to a roller in the cascable loop in order to give more lift. In mounting, the platform would be brought into the casemate and the gun parbuckled on to it; and in dismounting, the gun would be lowered on to the platform after the carriage is removed.

In certain casemates having three overhead bolts the platform may be brought into the casemate upside down on rollers, and turned over with a gyn tackle at the centre overhead bolt, then traversed to a flank. The carriage is then brought in on rollers raised by tackles and lowered on to the platform, both being then traversed to a flank. The gun and sleigh is then brought in and raised until the breech tackle is block and block: the muzzle is lashed up to the front overhead bolts, the carriage and platform

are traversed under, and the gun is lowered into the trunnion holes by easing off the breech tackle.

3. By jacks alone, as described for guns in open batteries.

Box Beam Apparatus.—This is used in casemates of not less height than 9 feet 6 inches for mounting or dismounting 38-ton guns.

The box beam is of wrought iron, about 11 feet in length, and curved upwards in the centre to clear the gun: it weighs 17½ cwt.

Two main screws, 5 feet long and 3 inches in diameter, pass through holes near the ends of the box beam, and are secured by nuts to washer plates and bolts fixed permanently into the roof of the casemate. The gun is suspended to each end of the box beam by bent bolts which pass round the trunnion studs and through the ends of the beam. The box beam, with the gun attached to it, is raised or lowered by means of two hydraulic jacks placed under its ends.

The gun having been brought into the casemate the box beam would be placed over it, the main screws attached to the roof and beam by nuts; the gun then attached to the box beam by the loop bolts. 30-ton jacks are used at either end to raise the beam and gun, and the beam is followed up by the spherical nuts on its under surface: the beam is then raised up to the roof and the gun thus left suspended; the carriage is then raised up to the gun, the platform brought in underneath and the carriage then lowered off into position, and afterwards the gun into the trunnion holes by means of the jacks.

In casemates 12 feet in height or in open batteries the box beam is suspended from a wooden frame instead of from the roof. The frame consists of two pairs of teak posts 9 feet 6 inches in length and 10 inches × 10 inches in section, their feet standing on wrought-iron bases, and their heads fitted with wrought-iron caps. Two cross beams, 10 inches × 10 inches in section, are bolted into the wrought-iron caps at the head of the uprights and secured by diagonal stays. The entire weight of the gun and beams is taken by the wrought-iron caps on the head of the teak posts, the cross beam serving to steady the uprights.

Moving Guns.—The methods of moving guns on land are:

1. By railway trolly: suitable for all guns.
2. By drug: up to 25 tons: over hard surfaces.
3. Sling wagon or cart: guns up to 5 tons by sling wagon, and up to 12 tons by two sling wagons; up to 64-pr. by sling cart.
4. Platform wagon: up to 70 cwt.
5. Sleigh: all guns, but temporary sleighs only suitable up to 12-ton guns.

6. Rollers: all guns.
7. Travelling carriage: up to 70 cwt.
8. Parbuckling: all guns.

Carriages, Mounting, &c.—Wrought-iron sliding carriages can be mounted and dismounted up or down the rear of their platforms by means of long skids placed between the carriage and sides of the platform, the carriage being further raised to the requisite height by planks placed across. The rear rollers are brought into play and the carriage hauled up or down the rear; the long skids being allowed to tip as the carriage comes over the rear of the platform. They can also be mounted and dismounted up or down the sides of their platforms by placing oak pieces under each bracket, lashing them together, and forming an incline by two long skids.

They can be transported by drugs; on their platforms; on a temporary sleigh; or on long skids by bringing the rear rollers into play.

Moving Platforms, &c.—Wrought-iron traversing platforms are moved by transporting axle and dilly, by temporary sleigh, or upside down on rollers; up to 12 tons the gun may be transported on the platform, in case of necessity.

In the case of a temporary sleigh long skids are placed fore and aft, inside or outside the trucks as may be most convenient, and fir planks or 6-foot skids are placed across to raise the platform so that everything is clear of the rollers or ground; short rollers being used on each side when the skids are placed outside.

When the platform is fitted with traversing gear it is generally more convenient to turn it upside down by means of a gyn or overhead tackle over the centre of gravity of the platform, or by means of tackles and levers. The platform can then be conveniently transported on rollers.

CHAPTER XIII.

GUNNERY.

The gunnery terms of the most practical importance will be understood from the diagram in Plate XIX. The diagrams also explain the different natures of artillery fire with reference to both the horizontal and vertical planes.

Notes on Laying.—A piece of ordnance is said to be laid point-blank on an object when the angle of elevation is nil: that is, when the line of sight and axis of the piece are parallel. The

quadrant angle of elevation or depression is the angle of inclination of the axis of the piece to the horizontal plane.

Every piece on firing has a tendency to revolve on the point of the trail or rear of the carriage or platform, the muzzle consequently rising: this is termed the "jump" of the gun, and it has the effect of giving more elevation and so increasing the range.

In order to insure accurate shooting it is necessary to take the following precautions:—

1. Lay with a full sight, that is, bring the object, the top of the fore sight, and the top of the notch of the hind sight in line.

2. The last motion of the elevating screw or gear should be one of depression in order to obviate any error due to the play of the gear.

3. The eye should be kept from 1 foot to 18 inches from the hind sight, and in all subsequent rounds the same uniform distance should be preserved.

4. In laying on fixed objects, some conspicuous part of the target should be chosen and all allowances necessary should be made on the elevation and deflection scales.

Rules for Deflection.—One minute on the deflection leaf gives one inch in every hundred yards: consequently to find the amount of deflection necessary to counteract any error, reduce the error (or distance the projectile falls to right or left) to inches, and divide by the number of hundreds of yards of range; the quotient is the deflection in minutes, which is given towards the side you wish the shot to travel: thus at 1200 yards range the shot falls 10 feet to the right; then 10 feet equals 120 inches, which divided by 12 gives 10 minutes deflection necessary and in this case left deflection.

If one wheel or trunnion is lower than the other, the projectile will tend to travel to the lowest side. The rough rule for correction is, multiply the difference of level of the wheels in inches by the number of degrees of elevation, for the number of minutes of deflection, to be given to the side of the highest wheel; or, multiply the angle of inclination of the trunnions in minutes by the number of degrees of elevation and divide by 60, for the number of minutes of deflection. Thus in first case, if right wheel is 3 inches higher than the left at 3 degrees of elevation, then 3×3 equals 9 minutes right deflection would be necessary.

Firing at Moving Objects.—In firing at an object moving across the front, calculate the distance the object will move during the time of flight of the shell; reduce it to inches and divide by the number of hundreds of yards of range. The deflection thus found is to be given in the direction the object is moving, and the gun fired

as the object crosses the line of sight. The rough rule laid down is to multiply the rate in miles per hour that the object is moving by 5 for minutes of deflection. If the object is moving 7 miles an hour at 1200 yards range and the time of flight is 4 seconds, then since 7 miles an hour is equivalent to 13 yards in 4 seconds, 13 multiplied by 36 divided by 12 equals 39 minutes of deflection: the rough rule would give 35 minutes (7 multiplied by 5).

Another plan is to traverse the gun sufficiently in front and to fire when the object has arrived at the distance for which allowance has to be made.

If the object is advancing on or retiring from the battery, the range is continually decreasing or increasing, and the gun would be laid on a spot in front of the object at the estimated range.

If the object is moving obliquely across the front of a battery, which would most commonly be the case, then the range and deflection are both continually altering, and in the absence of special range and position finders, considerable experience is necessary to insure anything like accurate shooting.

Varying causes may affect the amount of elevation or deflection necessary to be given. The amount of deflection necessary on account of wind must be judged. The state of the atmosphere, the condition of the powder, wind, and the amount of jump &c., will also alter the amount of elevation necessary for any given range. The yards scale and also the fuze scale can only be considered as approximate guides for the number laying a gun.

On Gun Practice.

The targets are placed according to local circumstances; and as a guide in placing them and also in deciding whether a range is clear, it is to be noted that projectiles fired at 10 degrees of elevation and under may range as follows:—12-pr. to 63-ton B.L. guns to 6000 yards in the case of the former, and 14,000 yards in the case of the latter. Heavy R.M.L. guns to 6000 yards; 40-pr. R.B.L., 64-pr. converted, and 7-inch R.B.L. gun to 6000 yards. R.M.L. field guns to 4500 yards. And 800 to 1000 yards, right or left of the line of fire.*

To note the results of the practice, a "range party" of sufficient strength is detailed under an officer, who is responsible that the range report is accurately kept. Communication by means of signals should be kept up between this party and the battery.

With shot or plugged shell practice, range parties should not

* Above from Shoeburyness regulations. These extreme ranges include ricochet on hard flat sands.

be placed nearer to the line of fire than 100 yards. With shell practice from 500 to 600 yards.

During practice it is essential to form a correct estimate of the range of the "burst" or point of impact of projectiles, as on this efficiency of fire *mainly* depends. Each No. 1 laying a gun estimates the range and deflection of his shot, and point of burst or graze of the shell.

Continued practice in judging distances in connection, if possible, with the use of range-finders is most essential.

Range-finders.—There are three range-finders in use in artillery service.

1. Watkin's Field Range-finder.
2. Watkin's Depression Range-finder.
3. Nolan's Range-finder.

Watkin's Field Range-finder is issued to field artillery: a full description of the method of using the instrument is contained in a Handbook and also in the Manual for Field Artillery.

The Depression Range-finder is for use in elevated batteries, and is issued to all coast batteries in or near which a height of 60 feet or more above mean tide-level can be obtained.

The Nolan Range-finder is issued to coast batteries and also to the siege train. It consists of two instruments on tripods, a calculating roller of metal, a tape, short cord, and reading glass. Its use, &c., is fully described in a Handbook.

Effect of Artillery Fire on Material.*

On Armour.—Armour plates may be destroyed by punching or racking. In the former case the projectile, having a high velocity and comparatively small diameter, has to be driven completely through the armour plate, and the fragments of the projectile take effect on the guns, &c., behind it; or if the hole is near the water-line the ship would soon be out of action. If the plate is too thick for perforation, the energy of the projectile must be utilised in racking, or cracking the armour and shaking it from its supports. Plates of wrought iron yield to perforation, but resist racking; in the case of steel plates, the converse holds good.

Compound plates are of iron, faced with steel. From the hardness of the latter metal, plates of this nature exhibit high power of resistance to penetration.

The penetration of common shell into armour plates is not inconsiderable, the common shell of the 10-inch R.M.L. gun fired with a battering charge will pierce a 5-inch iron unbacked armour

* Colonel F. G. Baylay, R.A.

plate at 70 yards. If the armour plate can be pierced, the large bursting charge of the common shell is particularly destructive.

On Wood.—The effect of a projectile fired against wood depends on the nature of the wood, the direction of the blow with regard to the fibre of the wood, and the diameter of the projectile. Oak resists artillery best; and the resistance is greatest when the fibre is arranged perpendicularly to the line of fire.

On Earth.—The effect of common shell of large capacity on earthworks is very marked, and even Palliser shell (if of large calibre) displace considerable masses of earth by the force of impact alone. Provided the fire is accurate, the most formidable earthworks can be speedily breached by pieces possessing large shell power.

On Masonry.—Projectiles fired at high velocity into masonry cut a tunnel of considerably larger diameter than their own, and the disturbing effect (independent of the power of burst) is generally widely distributed throughout the mass. Concrete has been found to afford inferior powers of resistance to good masonry (hard bricks set in cement).

Definition of Energy.

Energy.—When a projectile is moving, it is capable of overcoming resistance or doing a certain amount of work; this is termed the energy of the projectile.

$$\text{Energy} = \frac{\text{weight of projectile} \times (\text{its velocity})^2}{2\,(\text{force of gravity})}$$

$$\text{or} \quad E = \frac{W V^2}{2g} \text{ foot-pounds}$$

$$= \frac{W V^2}{2g \times 2240} \text{ foot-tons.}$$

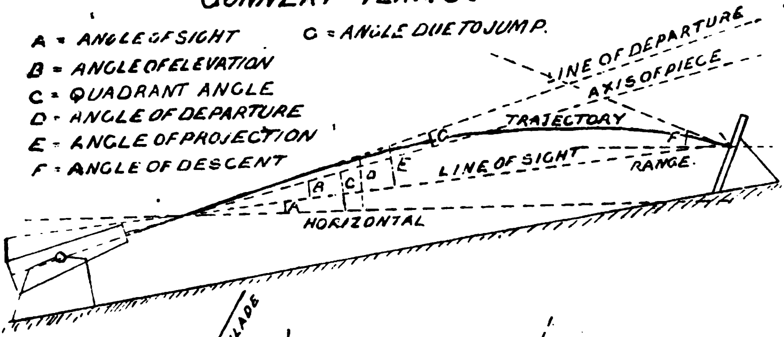
Thus the 10-inch R.M.L. gun firing a projectile of 400 lb. with a muzzle velocity of 1364 foot-seconds has a muzzle energy of

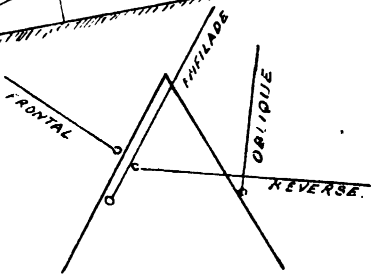
$$\frac{400 \times (1364)^2}{2 \times 32 \cdot 19 \times 2240} = 5160 \text{ foot-tons.}$$

In order to compare the power of guns for piercing armour plates, the energy is divided by the number of inches of the shot's circumference.

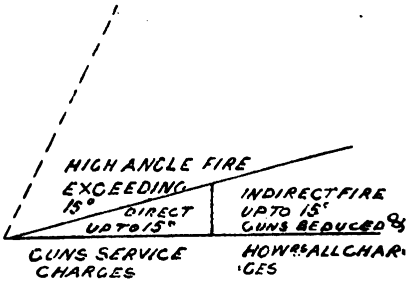
GUNNERY TERMS.

PL. XIX.

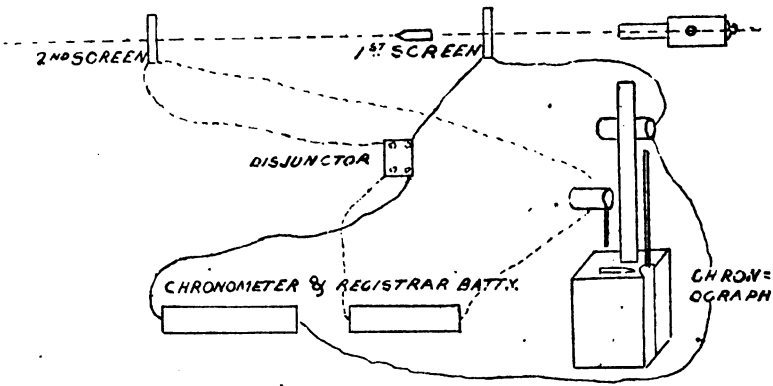




FIRE WITH REF^{CE} TO HORIZONTAL PLANE.



FIRE IN VERTICAL PLANE.



LE BOULENGÉ CHRONOGRAPH.

[To face p. 107.

Thus in the case of the 10-inch the muzzle energy per inch of shot's circumference is

$$\frac{5160}{\pi d} = \frac{5160}{3 \cdot 1416 \times 9 \cdot 92} = 165 \cdot 6 \text{ foot-tons.}$$

It will be observed that the energy stored up in a projectile as it leaves the gun increases as the square of its velocity: thus a small increment of muzzle velocity adds considerably to the muzzle energy. New-type guns have a muzzle velocity of 1800 to 2000 foot-seconds, and their muzzle energy is consequently very great in comparison with the corresponding natures of old-type R.M.L. guns, whose muzzle velocity is from 1200 to 1400 foot-seconds.

Instruments for Measuring Velocities and Pressures.

Boulengé's Chronograph.—In order to measure the muzzle velocity of a projectile, Boulengé's chronograph is used (Pl. XIX.), in which electricity is the agent employed. Frames with wire stretched across them in connection with primary circuits are placed so that the shot shall cut the wires successively, thereby interrupting the electric currents which pass through them and the instrument connected with them. The frames are 120 feet apart, and the first screen 30 feet from the muzzle.* Then since $\frac{\text{space}}{\text{time}}$ equals the velocity at the middle point, in this case 90 feet from the muzzle, and supposing the time the projectile takes to pass between the screens is found to be $\cdot 1$ second, then $\frac{120}{\cdot 1}$ equals 1200, so that 1200 foot-seconds would be the velocity of the projectile half-way between the screens, from which the muzzle velocity is calculated.

A description of the instrument will be found in the R.G.F. treatise: but briefly, it consists of a "chronometer" or long rod which falls when the current which holds it up is broken by the shot passing through the first screen (*vide* Fig.). A second short rod termed the "registrar" falls when the shot passes through the second screen, and breaks the second current: this registrar in falling acts on a lever and trigger which releases a circular knife, the latter flies forward and marks the chronometer rod which has a casing of zinc over it. By this mark the interval

* Sometimes more: for the first screen must be far enough off to be free from the destructive effect of the blast on firing.

that elapsed between the interruption of the two currents is ascertained. A graduated rule is used for measuring the height of the indent above the rear mark, and by means of a scale on it the velocity of the projectile can be read off without any calculation.

The Crusher Gauge is used to measure the pressure at any point in the bore, being inserted in the gun at that point. The instrument consists of a steel bush with a movable base or nozzle secured on to it. In a chamber inside there is placed a copper cylinder half an inch in length and $\frac{1}{12}$th of a square inch in sectional area. One end rests against a steel anvil and the other end is acted on by a piston. A hole is bored in the gun and the gauge is screwed in. On discharge the copper cylinder is crushed between the piston and anvil, and the amount of compression indicates the pressure exerted by the powder gas at that point. Its length after compression is read by means of a micrometer reading to one-thousandth of an inch; and by reference to tabulated results of previous compressions of similar coppers, the pressure in tons on the square inch is given without any calculation. Crusher gauges are also used screwed into the base of projectiles, in which case a record is obtained of the maximum pressure to which the projectile has been subjected.

The Noble Chronoscope is employed for measuring the velocity at very small intervals along the bore, and hence calculating the pressures in the bore. The precise instant at which a shot passes certain defined points in the bore are registered on a recording surface by means of electric currents. The instrument consists of two parts, the mechanical arrangement for obtaining the necessary uniform speed of the recording surface and the electrical recording arrangement.

For proof of powder, Boulengé's instrument and the crusher gauge are used.

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